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COOLING TOWERS

Best Method of Construction and Relative Efficiency of Various Types

BY JOS. H. HART, PH. D.

Cooling towers and cooling tower practice represent one of the recent developments in the construction and operation of power plants. This development has been strictly along the line of increased economy in operation and has very little to do with the constructive details of the plant itself. With the rapid increase in the size of power plant units and with the resulting increase in economy of operation, there has arisen a necessity of limiting the locality of such plants to available water supplies. The quantity of water consumed by a modern power plant of not abnormal size is remarkable. Where natural sources are unavailable and the water must be purchased from the city mains, the water bill is no inconsiderable item, and cooling tower installations have been adopted with the object of eliminating this limitation of locality.

The progress of cooling tower development has been so rapid that all engineering information on this development is in a somewhat chaotic state, and comparatively little is known in regard to best methods of construction and the relative efficiency of various types. A cooling tower in power plant construction is simply a device to cool off the condenser water, so that it can be used over and over again, without the constant demand for a fresh supply of cold water from the city mains or a large drain on the pumps. Thus cooling towers have been installed for two entirely different purposes,—in the first case, where water is unavailable, except at extreme cost; and second, where water is available, but of an undesirable quality. This cost factor may arise from a lack of available water or the necessity of its purchase at exhorbitant rates from a contiguous water plant, or from the large expenditure involved in installing and maintaining in operation suitable pumps. This latter condition is not often a determining factor and only in extreme cases should cooling towers be installed on this account alone. But the other conditions are sufficient in numerous cases to render its installation necessary.

There are several types of cooling towers on the market. These types differ in constructive details only; all utilize the absorptive power of air for water vapor to produce cooling in the water. The subject of moisture in the air and hygrometry in general is in a rather experimental stage from a practical engineering point of view, and comparatively little data is available to the ordinary engineer. Even the instruments for its measurement are unfamiliar and often unavailable for utilization. Cooling towers depend strictly upon this latter development. The conception that they cool the water by conduction is a fallacy and has led to a number of objectionable constructive details and much wrong theory on the subject. Thus cooling towers are of the atmospheric or closed type. The cooling tower consists of a large upright framework of wood, or metal, with a sprinkling device at the top and suitable pans or obstructions interposed to retain the water and present a large surface for contact with the air. In the atmospheric tower this framework is open and the air enters from the side and is propelled by atmospheric conditions only. In the closed type or fan cooling tower a large air blast is maintained mechanically at the base of the tower which forces the draft up and over the various devices holding the water.

It was formerly believed that the efficiency of the cooling tower depended simply upon the amount of water surface in contact with the air and the amount of air that could be brought into intimate contact with it. Thus the forced draft tower was generally considered to be the best, as much greater quantities of air could be driven from the tower in a given time interval. That this is not so is now an accepted fact, and is due to conditions not formerly considered. Thus water vapor in the air behaves precisely as though the air were not present. This is due to the remarkable fact that two vapors or a vapor and a gas can occupy the same space and obey Boyle's law just as though the other were not present. Thus the space entirely surrounding the earth is filled with water vapor and the science of this department of physics is known as hygrometry. The quantity of moisture in a unit volume of the space is readily determinable and depends simply upon the temperature and degree of saturation. Water vapor in the air behaves simply as any other vapor and becomes saturated on contact with a liquid of its own material. Thus in the vicinity of large bodies of water the water vapor is saturated. At greater distances this vapor is an unsaturated one and tends to become saturated when brought in contact with its own liquid. This principle is well known in steam

practice and is utilized to a greater or less extent in superheaters.

The ratio of the quantity of vapor present in a unit volume of space to the quantity that the space would contain if the vapor were saturated at that pressure and temperature is known as the hygrometric state. Thus the space surrounding the earth in these latitudes contains about 1/20 of a pound of water in summer and about 1/80th of this quantity in winter. When brought in contact with water it practically doubles this amount in summer and absorbs only a fraction of it in winter. Thus a cooling tower operates by the evaporation of a portion of the water and the absorption from the remainder of this latent heat of evaporation. The air acts merely as a carrier of this water vapor. Thus in mechanical draft towers the water vapor on entrance to the tower almost immediately becomes saturated and the remainder of its journey over the water surface is an economic waste. This is now generally recognized. The anomalous condition exists to-day that the hotter the air which enters the cooling tower the more efficient the cooling tower is in the performance of its duty. This is due to the fact that the absorptive capacity of water vapor is greater or that the saturation point is higher at this temperature.

Air is notoriously a bad conductor of heat, and while there is no doubt that some heat is given to the water by air hotter than it is, the conditions are such that this is far more than counterbalanced by the absorption by hot air of moisture. This is somewhat analogous to the utilization of superheated steam for drying purposes. The action is precisely similar and the heating effect of such steam is practically negligible, owing to the cooling produced by the latent heat of evaporation of the water absorbed.

Thus we see the reason why artificial draft towers do not compare with natural ones. This use of artificial draft is a mistake that has been often made in the last few years in the installation in power plants, and considerable money has been wasted in this development. The best cooling tower is the side-draft open-air arrangement, even though considerable water may be carried off in the form of a fine spray by a strong wind. Another mistake that is often made in the installation of cooling towers is due to non-consideration of the fact that the water consumption is not entirely eliminated. Cooling towers at their best efficiency evaporate 10 per cent. of the water which enters them. This must be steadily renewed, and the result is merely a reduction in this item rather than its total elimination. In large installations, however, this has been found to merely cut slightly the remarkable efficiency of such a development.

Now, cooling towers in their constructive details are in their inception. No two makers of cooling towers have identical plans or data for use in estimates. Thus cooling towers of the same capacity are of various heights and dimensions, chosen, apparently, at the option of the contractor. Some are covered with a lattice or screen, to prevent loss in a fine spray during a high wind, and others pay no attention to this development. In regard to the materials used in construction, many are made entirely of wood, others entirely of iron, and some use combinations of these materials, while one or two utilize reinforced concrete. The deteriorating effect on the structure due to the intimate contact of the water and air in this condition is very great, and a suitable constructive material has not as yet been found, when all the factors of first cost, durability and installation are considered. In some, large pans only are used, while in others, overlapping boards, shingles, shavings, or metal slabs are used to present a large surface over which the water must run and to which the air has contact.

Now, while cooling towers have had their inception and most marked development in power plant practice, in the elimination of the water expense for steam condensation, they are utilized to a greater or less extent wherever it becomes desirable to cool large quantities of water. Thus in refrigerating plants they are used to a greater or less extent to cool the condenser water in both the absorption and compression machines. The quantity of water used in these plants, unit for unit, is much larger than in power plants, since these latter may also utilize them for their steam condensation. In this development the initial temperature is not so high and the final temperature must be considerable lower. Their efficiency in this developmnt is scarcely half of that of power plant practice, and yet they have come into general and satisfactory use in this development is scarcely half of that of power plant praccooling purposes in place of refrigerating plants, as the cooling effect is often most pronounced. There are a large number of other developments in which their utilization is available and desirable, but few possess the prime conditions for efficiency that are present in power plant operation.

It can be said to-day that even in plants where a large supply of water is available, if the pumping is inefficient this installation presents a possible economy, and this statement becomes doubly true if the water is at all impure or unsuitable for boiler purposes. This is often the case, and it can be said off-hand that a cooling tower installation is much more efficient if any attention at all has to be paid to the purification of the water. It is eminently desirable, however, that standard types be developed in this line and experiments made to develop a suitable material for construction obtained. Reinforced concrete, if rendered properly water-proof, appears to present the best possibilities. Slate offers an attractive substitute, but has never been tried, and it is eminently desirable that this branch of engineering, which offers greater advantages in increased efficiency than many of the modern developments in super-heaters and steam jackets, should be developed to its maximum efficiency.

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New Power Plant for the Government.

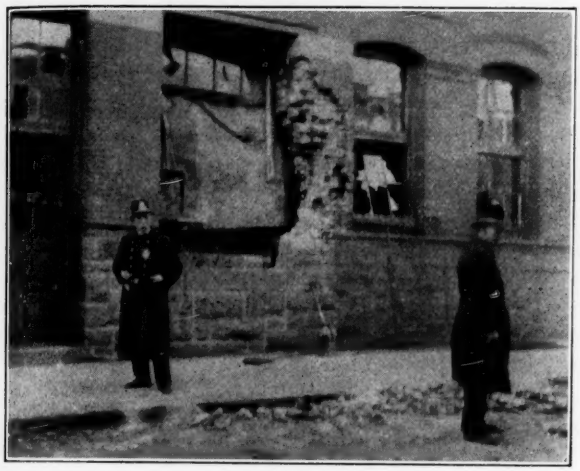
The United States Government, after two years of consideration of plans and equipment, has awarded the contracts for the new Central Power Station, which is now in the course of construction at Washington. It will be a most modern plant, situated about four blocks south of the Capitol in Garfield Park, and will furnish heat, light and power for the group of buildings immediately surrounding the Capitol; namely, the Congressional Library, the new Senate and House office buildings, and the Capitol itself.

The contract calls for sixteen 600 horsepower, high pressure Atlas water tube boilers and four 2,000 k. w. Westinghouse-Parsons turbines, which are to be delivered prior to the first of next year, at which time the plant, it is hoped, will be in actual operation. The order for boilers is the largest ever placed by the government, and the plant, when completed, will be one of the largest and most modern of its kind in the United States.

Electric Light Plant Wrecked by Fly-Wheel Explosion

Broken Belt Caused Runaway Engine

At midnight, March 24th, a large portion of the northern part of Philadelphia was thrown in total darkness by the bursting of a large flywheel in one of the plants of the Philadelphia Electric Co., located at American Street and Susquehanna Avenue. This plant is one of a number belonging to the same company which supplies the street arc lighting



Side of Power House showing the 27-inch Brick Wall through which two pieces of the Fly-Wheel were projected

throughout the city of Philadelphia, and when the accident happened the plant was carrying its maximum load.

The plant was equipped with two 1500-horsepower cross compound condensing Wetherill-Corliss engines, belted to 16-150 light arc machines. The engines and boilers were located on the ground floor and the electrical machinery and switchboard was located on the second floor. Each engine was run under and was belted back to a countershaft on the engine room floor, the smaller belts being carried from each pulley on the countershaft through the floor to the individual generators above.

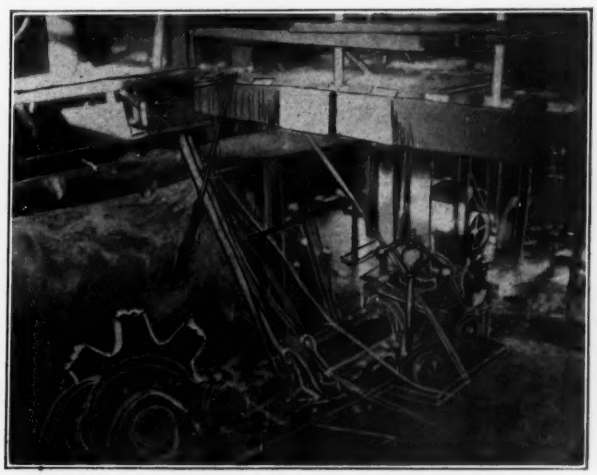
It was one of the flywheels of these engines that exploded, and as a result the power house was partially demolished, two dwellings across the street were rendered uninhabitable, the steam main was broken, and besides completely wrecking the engine, the arc light switchboard was demolished and all the belts in the plant were ruined by the escaping steam. Fortunately no one was killed, the only casualties being the injury of the night engineer, who was scalded by the escaping steam after the explosion, while attemping to shut off the main steam valve leading to the engine room.

The accident was caused by the breaking of the main belt, which, when it broke, wrapped itself around the governor mechanism and tore away the reach rods, thus preventing the governors from acting and causing the valves to ride the full length of the stroke. The engine, being under the full pressure of steam, soon acquired enormous velocity and the flywheel was the first thing to give away.

The flywheel was 20 feet in diameter and was composed of eight segments, bolted together at the rim. The arms of the wheel were of cruciform shape and were securely set in recesses in the hub and bolted to it with through bolts. The face of the flywheel was 48 inches wide and the whole wheel weighed ten tons.

When the flywheel exploded the pieces of it took three distinct paths. One section weighing about three tons went up through the roof, tearing a hole in the second floor twenty feet in diameter, and one in the roof about thirty feet in diameter. This immense casting rose high in the air and in falling crashed through the roof of the boiler house and landed on one of the boilers, doing but little damage to it. Another piece of the wheel weighing about 1000 pounds, five feet long and three feet wide, after passing through the 27-inch brick wall of the power house, struck the front door of a dwelling across the street and broke it down. It then passed through the parlor, through a stairway, across the dining-room, across the kitchen and out of the back wall of the house, completely stripping the lower floor in its passage. The front of the adjoining residence was torn out by the terrific jar. Another and larger piece of the flywheel, weighing about 1800 pounds, knocked a hole six feet wide in the basement of the house and carried away the basement stairs. The sidewalk in front of the adjoining residence was also torn out by this flying piece of metal in its passage into the building.

With the exception of the large pieces which destroyed the boiler house and the dwellings, but little of the immense wheel could be found, and it is supposed that the remaining pieces were scattered far and wide in small fragments. The spokes were all broken off close to the hub with the exception of one which remained intact. One small piece must have been carried some distance, as it was noticed that the chimney had a piece chewed out of it at a height of about 150 feet by one of the flying fragments.



Wreck of the 1500 H. P. Cross Compound Engine after the Fly-Wheel Explosion

An examination of the portions of the wheel found after the explosion showed them to be of good iron and no flaws were detected. The engines had been in service a number of years, carrying practically the same load each night.

HIGH TENSION LIGHTNING ARRESTERS

By C. Pagano.

There are generally two great dangers which threaten electrical equipment, especially power stations; namely, lightning and static charges. In both cases the potential difference is very high and such as to puncture the insulation through which it happens to pass.

To protect a plant from lightning charges, choke coils and arresters are provided in the main line, but sometimes they fail to respond, thus allowing high potentials to pass through the devices which they are designed to protect. The choke coils disposed in series in each side of a line have enough self-induction to repell a static charge back to the arrester in the main line, and the windings of the dynamos and transformers have a like self-induction, generally greater than that of the choke coils. However, in the presence of these two combined self-inductions, atmospheric charges, under special characteristics and forms, acquired from a complex of circumstances accompanying the discharge, find a way to flow to the ground through the windings of the apparatus.

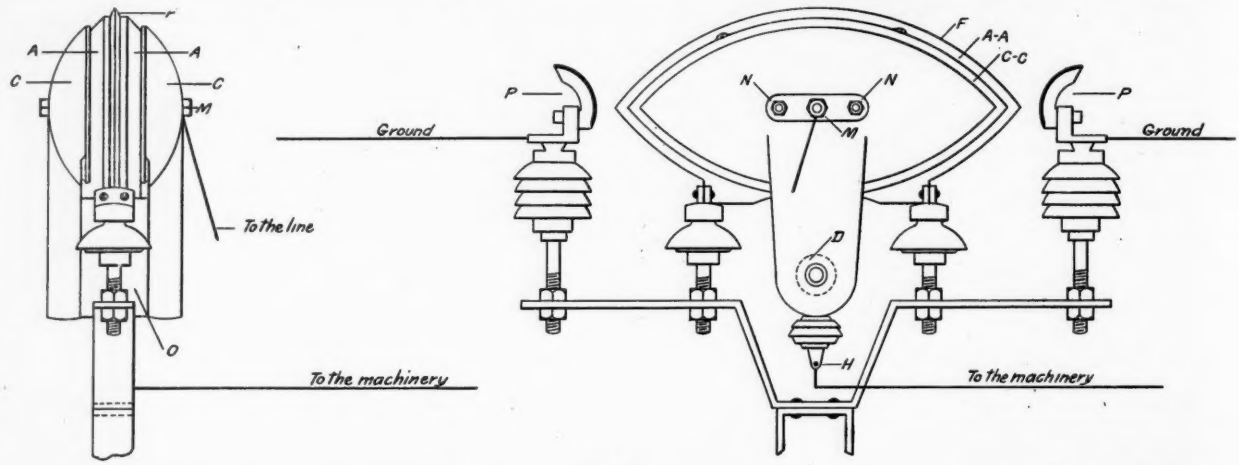


Fig. 1

On the other hand, the self-induction of the choke coils cannot be increased beyond a certain limit, and if it is increased it becomes sensible to the potential it furnishes to the machinery. Although a perfect positive path in principle is a useful one, its possibility to keep the explosive distances very near, offers to the atmospheric charges an easy path to the ground. Sometimes, however, the discharges through the main line of the machinery are larger than the explosive spaces of the arrester. Thus the field remains open for an apparatus in series to act every time and under every condition of the atmosphere like a sieve. Such an apparatus would permit the flow to the potential of service and reject back to a supplementary short line the atmospheric charges, which would then be compelled to jump across the arresters in the main line in order to get grounded. Such a device was designed by an Italian electrical engineer, a Mr. Gola, of Turin, North Italy.

In the Gola lightning arrester, the short supplementary line is erected in the proximity of the main line of the power house or sub-station, and connected to the ground. On this line is applied the arrester which forms the passage of the atmospheric charges, while on the main line the arrester is placed in series, allowing only the passage of the industrial current. The arrester in series, as shown in Fig. 1, is a large hollow body of magnetic material formed by two caps AA, which are held together by cross bolts and enclose a diaphram of anti-arching material, which extends over the edges of the caps like a border at acute angles, as shown at F. Side by side of the two caps, magnetically insulated from and electrically connected by the cross bolts NN, are placed two other caps CC. These caps enclose between their prolongations on the lower side a core of soft iron D. Inside the coil *h*, a terminal is connected internally to the hollow receptacle by the diaphragm F; the other end is insulated and goes to the machinery. The coil H is enclosed in a brass box O. Facing the acute corner F in two diametrically opposite points are the two conductors P and P, which are made of carbon or any anti-arching material, and are fixed on heavy porcelain insulators, constituting the grounded parts of the apparatus. The main line is broken in the direction of this arrester in series, the part coming from the machinery being united to the terminal of the coil H, and the part going out enclosed under the central nut M of one of the caps A and A.

The operation of the apparatus in a central station is as follows: The industrial current entering the box O, through the terminal H, flows through the coil at H and passes into the hollow receptacle, through the diaphram F. From thence it goes out on the external surface through the bolts N-N to the outside caps C and C and through the bolt M to the line of transmission. In case of a sub-station receiving the power, the path of the current would be the reverse. The ohmic resistance is negligible and the impedence is of the same value as that of the usual choke coils.

An atmospheric discharge coming from the outside arrives first on the bolt M, from which it flows on the caps C-C, which have a great external surface; from these caps the discharge next flows through the bolts N-N, which have a very small sur-

face. Hence the discharge from a large expansion must retain itself in order to pass on to the caps A-A, from where it receives again a large expansion. At these caps the discharge meets the two grounded conductors P and P, and passes through a space of air regulated according to the tension of service. This is the path of an outside atmospheric discharge according to the properties of the expansion on large surfaces.

On the other hand, in order for the discharge to reach the machinery and be grounded through its windings, the discharge would first have to enter inside of the hollow receptacle. From here it would have to go through the magnetic material, retaining its expansion, to a conductor of very little surface, as at the coil H, and then go to the machinery, after having lost the resistance of the self-induction of the coil H and the windings of the machinery. In the above instances we have seen that the many causes of impedence are summed together to oppose a strong resistance to the passage of an atmospheric discharge; and in the same manner this impedence acts against electrostatic or static charges.

When a charge occurs the highest potentials are produced on the external surfaces of the caps and the corner of the diaphram F, which faces the two grounded conductors. When the discharge jumps across the space between the conductors P-P and the diaphram F, an arc will be produced through which the industrial current would find a path to the ground, but the arrester on the short supplementary line breaks the arc, closing the path to any leakage. In case of a tension of four or five thousand volts, a simple ohmic resistance would be sufficient to extinguish the arc, but for higher tensions it is advisable to use other means.

The following method has been successfully employed in a large power house and found sensible even to the smaller discharges. In the grounded line of the arrester in series and parallel with its arc-breaking device, is placed a common horn arrester and an ohmic resistance, consisting of pipe of a special kind of clay shaped as a syphon and containing a light solution of bichloride of mercury in water. The small discharges as shown in Fig. 2 are grounded through the space A, overcoming the resistance R, while the strong charges pass to the ground through the space B.

The lightning arrester, no matter of what type it may be, should be placed a good distance from any metallic matter such as conductors, apparatus, etc., as the voltaic arc at high potential is a very bright and extremely movable flame which easily jumps on the surface of the surrounding metal, burning and eating it.

A good ground connection must be provided in order to have the arresters work satisfactorily, and the following method is recommended by the Westinghouse Co.: Drive a piece of galvanized iron pipe into the ground near the place where the line is to be grounded and surround the top of it with coke in order to retain moisture. The wire is run down the pole and connected to the top of the grounded pipe. If the wire is encased in another pipe for mechanical protection, the wire is soldered to the top of it. Another good method is to dig a hole 6 feet square and 6 feet deep as near as possible to the arrester. Cover the bottom of the hole with charcoal or coke crushed in small pieces for a depth of two feet. On this stratum lay a tinned copper plate five feet square with the grounded wire soldered across it and cover the plate with a two-foot layer of charcoal or coke and fill in with earth; using running water to settle it. This is a good ground connection in rich soil, but it is not suitable where the ground is formed of rock, sand or gravel. Where possible, a connection with an underground pipe system offers the best and easiest path to discharges because of the great surface contact with the earth and the numerous paths. In water plants the ground wire must be connected to the penstock. Generally the place where the plate of the grounded wire is buried must be kept in a constant state of humidity, and the wires connected to the plates and arresters must be as straight as possible, as bends are likely to offer resistance to the passage of the discharge.

The Gola lightning arrester is used throughout Italy and is spreading over all of Europe, and from personal inquiries it has never failed to respond to the purpose for which it was designed even in the most terrific disturbances of the atmosphere.

A good plan for every power house is to have catalogued all facts observed during atmospheric disturbances, noting the slightest abnormal conditions accompanying them, and the following scheme used by many engineers in Europe is a good one: Intensity of the storm; was it accompanied with rain and heat? the time it began; the time it ended; how long was the period of greatest intensity; what are the mechanical, physical and natural surroundings of the power house and the outside wires? condition of the lines before and after the storm;

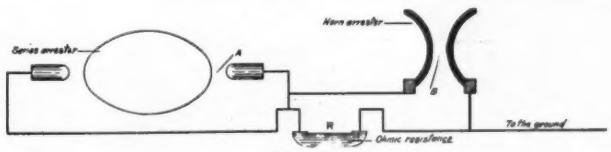


Fig. 2

facts observed on the lines, poles, wires, insulators, ground wire discharge plate, arresters and external fuses; the number of discharges on each arrester, and which had the most; which line was damaged and an analysis of it; facts observed in all sub-stations and transformer logs; potential of the station and lines during the storm; note any discharge which occurs on the power house, surrounding buildings and places along the line.

Any intelligent engineer, after a little practice and experience, can add other useful observations, such as the temperature; form of lightning flashes; distance of the storm; direction and intensity of the wind, etc. This would be the best and most practical method in studying the atmospheric phenomenon and obtain from a long and elaborate experience the means to invent a more suitable and efficient protective apparatus.

Large Power Plant Injured by Fire.

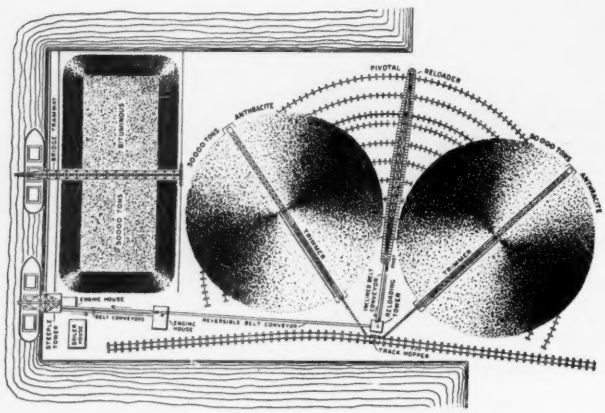
Early on the morning of April 8th, fire destroyed the combined car barn and power plant of the New York City Railway Company, located at 146th Street and Seventh Avenue. More than 300 cars were destroyed and the power plant was ruined. One fireman was killed under a falling wall and sixteen others were more or less injured. The fire started in the big repair room and was due to defective insulation on one of the cars. The flames spread with great rapidity to the power plant and practically all the machinery was ruined by fire and water except the electrical equipment in an adjoining five-story building.

COAL STORAGE PLANT AT SHADYSIDE, N. J.

Enormous Storage Facilities of the New York Edison Power Plants

The handling and storing of coal at the Shadyside (N. J.) plant of the New York Edison Co. is of more than passing interest, as facilities have been provided for a reserve supply of 100,000 tons of anthracite and 50,000 tons of bituminous, which may be drawn upon in case of emergency, such as would result from a tie-up of the railroads from any cause or combination of circumstances resulting in a coal famine.

On account of the fact that the large new waterside station of the company in the City of New York consumes 1,000 tons of coal per day on the average, and that the total coal bunker supply at the station would not hold out for more than about ten days if all further supply were cut off, the importance of the storage plant will be evident. On account of a lack of available space in close proximity to the station at Thirty-fourth Street and East River, in New York, the storage plant was located at Shadyside, N. J., a point on the Hudson River, about opposite 110th Street, in New York. Connections were made with the New York, Susquehanna and Western, and



Plan of the New Coal Storage Plant of the New York Edison Co., at Shadyside, N. J.

other railroads from the coal districts and the necessary dockage facilities are available for reshipment by boat to the stations in New York. A frontage of 460 feet and a depth of 1,500 feet was secured on the river, and at the water front a dock 20 feet in width was installed to carry the high speed hoisting tower and bridge tramway for handling to and from boats.

Two anthracite piles of 50,000 tons each have available space in the yards, and adjacent to the dock there is space for a 50,000 ton bituminous pile. The rear of the site is occupied by storehouses for miscellaneous storage for the company, and in addition there is room for an additional anthracite pile, if needed. The anthracite coal is handled by Dodge trimmers for piling and a Dodge radial pivotal reloader for removal, delivery being made by belt conveyors to the dock, where a steeple tower is installed for the loading and unloading of boats. The bituminous coal is stored in a rectangular pile, the handling to and fro being accomplished by a traversing bridge tramway which spans the pile.

The accompanying illustrations show the construction of the traversing bridge for the bituminous coal pile. A bridge is provided for carrying the trolley for cross movements of the coal bucket and has a span of 200 feet between centers of

Inclined Belt Conveyor, Steeple Tower and Clam-Shell Bucket.

support, the clear height under the trolley runway being sufficient to permit handling the bucket over a 30-foot pile of coal. The bridge is supported at the dock end by a tower 67 feet in height, which carries in the housing at its base the boiler and engines for operating the hoists, trolley traverse and longitudinal movements. The structure is carried on three lines of rails, extending over 400 feet long the line of

Anthracite Coal Piles and Pivotal Reloader.

the dock, so as to cover all parts of the pile, and is operated by its own power.

A two-ton clam shell bucket, which travels on a runway connecting with a boom projecting over the water, handles

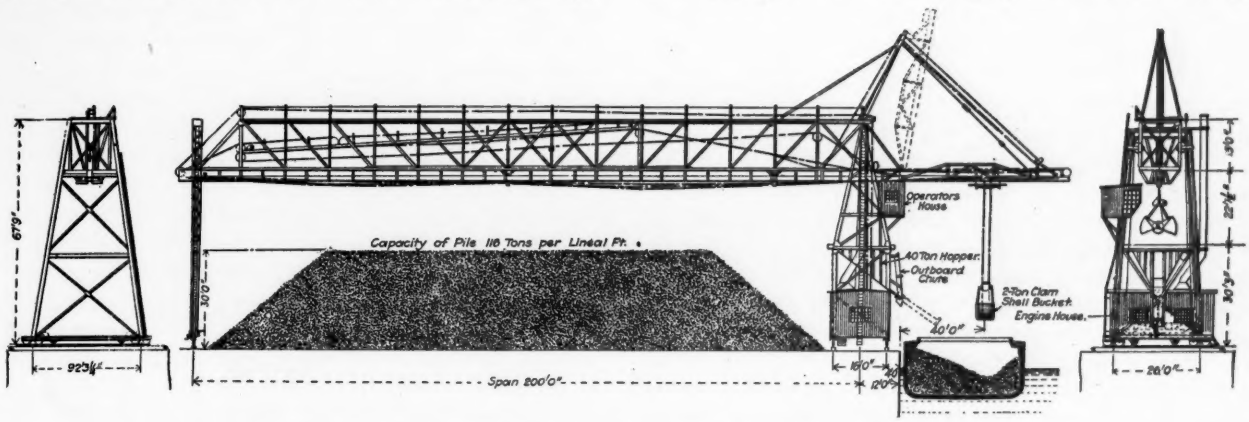
the coal in unloading from boats. The boom is of sufficient length to permit the bucket to be extended out 40 feet beyond the dock line, and it may be lifted to a vertical position to permit of masted vessels passing when docking. For loading the vessels the bucket discharges into a 40-ton steel hopper above the engine housing, from which a swivelling outboard chute is hung for delivering and trimming. Two standard engines are used for the operation of the bucket, one for the closing and hoisting, and the other for the trolley traverse; the former has 12 x 12 inch cylinders and the latter 10 x 12 inch cylinders. Steam is supplied to these engines by a 5 x 12 foot vertical tubular boiler, also carried in the tower.

The anthracite handling plant is designed for receiving either by boat or rail, but the bituminous coal is arranged for handling only by boat. The anthracite coal is dumped from cars directly into a track hopper, from which the Dodge trimmers distribute it to the circular piles when received by rail. The trimmers are of the standard inclined truss Dodge type with scraper conveyer leading up one side; openings in the scraper trough permit the coal to be dumped at any point on the pile desired. When the coal is received by boat it is handled by a steeple tower at the dock, which, by means of a 1.5 ton clam shell bucket, lifts the coal onto a belt conveyor system; this extends back and delivers into the track hopper near the anthracite piles which feed the trimmers the same as when received by rail.

A steeple tower is located on the docks permanently and has a total height of 90 feet, while the overhanging boom permits of an extreme position of the bucket 30 feet beyond the dock line. The trolley runway extends back over a 40-ton hopper in the upper part of the tower, below which are two weighing hoppers, and below these a discharging hopper for delivering the coal received to the belt conveyor leading back to the trimmers. The 40-ton hopper into which the clam shell bucket dumps has sufficient capacity to keep the weighing process continuously in operation when unloading from boat. The weighing is accomplished by keeping the two weighing hoppers, which are of five tons capacity each, alternately filling and dumping; when one becomes filled the feed is shifted to the other, etc., so that the process is simplified to a mere counting of the number of times each hopper is filled.

In this tower the bucket is operated by double cylinder engines, consisting of a smaller engine superimposed above a larger one; the smaller, which has 10" x 12" cylinders, operates the trolley, while the larger, with 15" x 24" cylinders, operates the bucket closing and hoist. These engines are both of the direct connected type, so that the hoisting and traversing movements are unusually rapid; the cable drums, which are 30" and 32" in diameter respectively, are mounted directly upon the engine shafts, being connected at will by special friction clutches. These are controlled from the operating houses for all movements, the hoist by one man and the traverse by another, for facilitating the work. Very rapid unloading has been secured with this arrangement, as many as four trips per minute being possible under favorable conditions, and 2.5 trips per minute, or 150 per hour, being an average working rate, or a capacity of 225 tons per hour.

The belt conveyors and the arrangement of the same is shown in the accompanying drawing of the yard plan. A 24" reversible belt conveyor extends from the track hopper between the trimmers to the engine house, where it discharges onto a 24" inclined belt conveyor, delivering up into the 40-ton hopper in the tower for loading onto vessels, or receives by another inclined descending belt conveyor of the same size coal that is taken from vessels and weighed in steeple tower and discharges it onto the storage piles. The belts are operated at a speed of 600 feet per minute, being driven by a 12 x 16-inch single engine located in the small engine house situated midway between steeple tower and storage piles. The combined capacity of the unloading and weighing apparatus in the steeple tower and the belt conveyor system and trimmers is about 800 tons per day of ten hours when operating under average conditions, although under the most favorable conditions nearly 1,200 tons have been handled in ten hours.



Transverse Gravity Bridge handling Bituminous Coal in Rectangular Pile.

For the removal of coal from the piles the reloading system includes a reversible side scraper conveyor of the pivotal type swinging over a radius of 300 feet, which delivers at its pivot to a 30" inclined belt, feeding 5-ton weighing hoppers that spout to the reversible conveyor. It is carried on ten lines of circular track, one of which is used for the cable mechanism for moving the reloader into the piles; the possible movement is sufficient to cover the entire area occupied by both piles. This reloader, as well as the trimmer mechanism, is operated by a 16 x 18" single engine located in a house at rear of reloader tower between the piles. The capacity of the reloader

is, under ordinary conditions, 1,500 tons per ten hours, although this rate has been considerably exceeded.

The three engine equipments are supplied with steam for operating the anthracite handling system by a boiler plant in a building near the dock, which also serves as an electric lighting plant, shop and office. There are two 6 x 18 foot horizontal tubular boilers rated at 150 horsepower each. The lighting plant comprises a 100 kw. General Electric 240-volt generator, which is direct connected to a 150 horsepower Ball and Wood simple engine, which is used for lighting the yard, about 250 incandescent lamps being distributed for night operation.

VAPORIZATION OF FUELS

Devices for the Preparation of Fuel for Use in an Exploding Engine

In a recent bulletin issued by the United States Department of Agriculture, Prof. Chas. E. Lucke, Assistant Professor of Mechanical Engineering, Columbia University, and S. M. Woodward, Engineer United States Experiment Stations, give some very interesting details about the use of alcohol and gasoline in internal combustion engines. The bulletin takes up in detail the comparative cost of energy from different sources and in different fuels, the adaptability of various types of engines, the first use of alcohol engines, elementary engine mechanism of the exploding engine, explosive mixtures, temperatures of ignition, liquid fuels, heat of combustion, vaporization of fuel and other practical experience with internal combustion engines. That part of the bulletin devoted to the vaporization of fuel is particularly interesting to the operating engineer and is given herewith in full.

Before any liquid fuel is available for use in an exploding engine it must be vaporized, and this vapor must be mixed with an air in the proper proportions—that is, as near the chemical proportions as may be possible. Thus the preparation for fuel for the use in an exploding engine involves three steps. First, vaporization; second, mixing with the air; third, adjustment of proportions. The devices used in the engines to accomplish these things show the widest variation of detail design. In some of these devices the fuel is boiled in a chamber which is then known as a vaporizer, and the vapor is allowed to flow into a stream of air entering the engine, the amount of vapor being regulated by a valve, just as is done in a gas engine. During the process of vaporization the air is not contact with the vapor as it forms. In the next type of vaporizer the fuel is dropped on a hot plate, over which the air flows on its way to the engine, and the proportions are fixed by the rate of air flow or by the rate at which the fuel is supplied to the hot plate or by the temperature of the plate. When the fuel will vaporize at a low temperature below that of the atmospheric air, it is not necessary to have any heated plate, and the fuel may be dropped directly into the entering stream of air, the proportions being adjusted by the opening of a small valve. Kerosene requires a plate or chamber quite considerably heated to completely vaporize it, as the boiling point is high. Gasoline requires nothing of this sort, as it easily vaporizes at atmospheric temperatures. Alcohol lies between these two fuels in this respect. It requires temperatures higher than the usual atmospheric temperatures, but not so high as those necessary for the kerosene.

A device for preparing the mixture in these engines, which performs three functions—vaporizing, mixing and proportioning—is called a carbureter. Carbureters are universally used for gasoline and similar easily vaporized substances. Vaporizers in one form or another are almost universally used for kerosene, although some kerosene carbureters have been devised differing from the gasoline carbureter chiefly by the addition of a heating part. Alcohol is used in both of these devices—that is to say, alcohol carbureters are common, and so are alcohol vaporizers, but the carbureters are more common than the vaporizers. An alcohol carbureter may differ not at all from a gasoline carbureter, but by reason of the high temperature of vaporization of the alcohol some method of heating either the air or the mixture is necessary to insure complete vaporization, and the more water present the higher the necessary temperature. In order that the above distinction may be clear and variations in the detail design for accomplishing the same purpose may be set forth, descriptions of a few typical devices are given.

One common form of pure vaporizer in use in the West is a retort, of the class involving the dropping of oil on a hot plate. This is shown in figures 1 and 2. The exhaust from the main engine enters the retort at the port (A). The hot exhaust gases heat a central drum, around which the generating wheel revolves. The generating wheel (C) is a hollow wheel or drum, containing channels or buckets on the periphery. This wheel

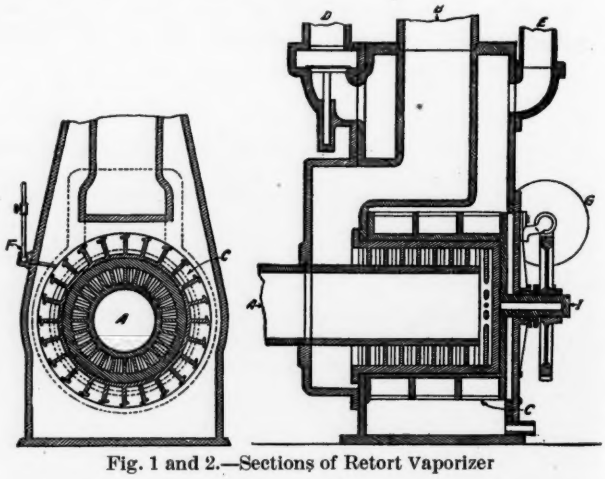


Fig. 1 and 2.—Sections of Retort Vaporizer

is driven by a belt from the main engine around a driving pulley (fig. 2, G), transmitting power through a worm and gear to the driving spindle (I). The driving spindle is attached to the generating wheel, which revolves about one-half turn a minute. The heat radiating from the heated drum is intercepted by the generating wheel and utilized in transforming the oil into gas as it is fed into the channels of the generating wheel through the oil port (fig. 1, F). As the oil

is fed into the channels through the oil port it is carried up and over the top of the wheel, giving up its volatile parts by reason of the heat received from the wheel. The nonvolatile portion of the oil, or the residuum, remains in the channels until they reach the bottom, where the residuum drops into a reservoir and is automatically drained off through the residue port by means of a pipe with a drop of 8 inches or more below the retort, having a horizontal check valve on the end. The check valve is for the purpose of keeping the residuum from being drawn into the engine cylinder.

The exhaust gases are carried away from the retort by means of a pipe screwed into a flange attached to the exhaust outlet (fig. 2, B). As the gas arises from the wheel from the gas chamber it circulates around a hot exhaust pipe, thus being superheated. It is immediately drawn into the main engine cylinder by the suction of the engine, through a connection of pipe and fittings from the gas port (fig. 2, D), to the inlet to the engine cylinder, where it is ignited by whatever means may be used for that purpose. Air is also drawn by the engine suction into and through the retort case, entering at the air inlet port (fig. 2, E). In some cases the air-inlet pipe, connected to this port, runs about two feet and then turns down again. This is recommended to prevent gas from escaping through the air inlet between the suctions.

There are no devices in the American market of any kind that specifically boils the fuel in a separate chamber. A device of this kind would have certain advantages over that of the simple hot plate type for the following reasons: If the plate on which the oil is dropped gets too hot, the fuel will decompose in addition to vaporizing, and leave on the plate a black sooty residue. This is because these fuels are very sensitive to decomposing from overheating. If the plates are not hot enough the fuel will be only partly vaporized, and good fuel will be thrown away as residue. When the heating is to be accomplished by the exhaust gases, not only must a lamp be supplied for initial heating, which takes a long time with such a mixing device as this, but further, and more important, the temperature of the vaporizing plates is very difficult if not impossible to regulate. On fluctuating loads, therefore, where the engine requires more or less vapor from time to time the hot-plate vaporizer would sometimes be decomposing fuel from excess heat; at other times only partly vaporizing it, and in any case proportions of air to vapor will be sure to be irregular, so that in the mixture there will sometimes be an excessive vapor and sometimes an excess of air. Such a hot-plate vaporizer, therefore, is adapted only to those oils that cannot be otherwise treated in carbureters. For this reason retorts of this kind are almost solely confined to engines which use the crude oils.

There is on the American market a class of engines having a vaporizer which forms part of the cylinder head and which is heated by the explosions taking place inside the exploding chamber. Otherwise stated, these vaporizers are themselves exploding chambers. One of these is shown in Fig. 3. On this figure, A is the vaporizer proper. Under it is seen a lamp (B) with a burner (C), and, to prevent undue radiation in heating, the burner and vaporizer are surrounded by a casing (D). This vaporizer is bolted to the cylinder head (E) and contains on its inner end a lip projecting into the exploding chamber. A little pump injects a small stream of oil at every stroke and drops it on this lip from the pipe (F). This lip is very hot from previous explosions and from the lamp, which, by the way, is turned off when the engine begins work. The compression stroke of the piston forces the air in the cylinder over the lip and through the neck into the vaporizer bulb, thus mixing more or less completely the vapor which formed on the lip with the air that is forced over the lip into the bulb. Such hot-bulb vaporizers as this will work with practically all of the fuels—crude oils, gasoline, kerosene and alcohol—with proper adjustments of the pump and of the temperature of the bulb. These bulbs perform another duty besides vaporizing

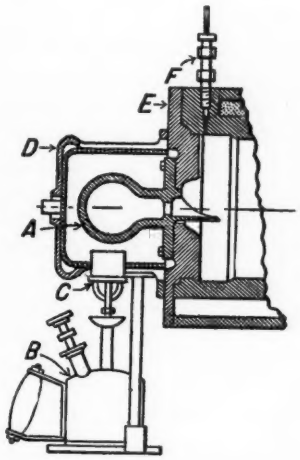


Fig. 3. Section of Hot Bulb Vaporizer

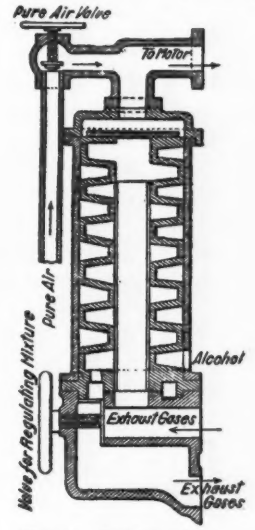


Fig. 4. Section of Brouhot Vaporizer

and mixing. Their high temperature, that of a red heat when in operation, is sufficient to ignite the mixture when the compression is high enough, thus eliminating any necessity for electric igniters. In engines fitted with this type of vaporizer no mixture enters the cylinder at all; nothing but air passes through the inlet valve. Oil is pumped in, drops on the vaporizer, there meets the air, with which a more or less complete mixture is formed, the mixture is compressed, and by the compression heated and ignited. This type of vaporizer igniter has, besides the above advantages, certain disadvantages: (1) The vapor is but imperfectly mixed in the air; (2) the exceedingly high temperature in the vaporizer, which it is impossible to avoid, will more than vaporize some of the fuel, decomposing it and depositing soot if the fuel be hydrocarbon; and (3) another bad feature in the use of such a vaporizer is to be found in the fact that some air remains between the piston head and the bulb, and this is inactive, no fuel being burnt, the only active part being that which enters the bulb. Engines fitted with vaporizers of this kind, therefore, cannot do as much work for the same size cylinder as an engine in which the entire mass of gases in the clearance is active explosive mixture. Furthermore, these engines will always use more fuel than is necessary because of the incomplete mixing of fuel vapor and air and the partial decomposition of some of the fuel.

Another vaporizer of the hot-plate sort, intended particularly for alcohol, illustrated in figure 4, is known as the Brouhot, a French type. Exhaust gas enters at the bottom, as shown by the arrow and lettering on the cut, and rises through the

iron chamber, which is corrugated to increase the surface without making the apparatus too bulky. Alcohol is admitted near the bottom of these ribs or corrugations and flows upward on the side opposite to that heated by the exhaust gases. The regulating valve is attached to permit some exhaust gases to pass around the heating chamber and so vary its temperature, but the regulation of temperature must be done by hand. Vapor rising from the surface of the alcohol in the top of the chamber meets air, which passes first through the regulating valve intended for the adjustment of proportions. The corrugations are such as to form a screw thread or a helix passage and the exhaust entering first at the bottom passes directly to the top of the chamber and downward in the helical grove to the bottom, so that the top of the helix will be the hottest part. Alcohol enters the bottom of the opposite helix, flows upward and vaporizes somewhere in its upward course, discharging into the air current at the hot top of the helix as superheated alcohol vapor. This vaporizer is, therefore, of the boiling type, but the boiling takes place on the surface of the liquid which is at the pressure in the suction pipe, and the rate of boiling is regulated by hand by admitting more or less exhaust gases to the vaporizing helix.

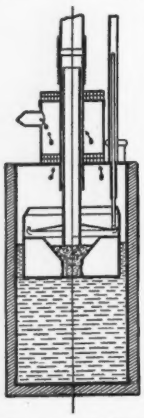


Fig. 5. Section of Daimler Carbureter

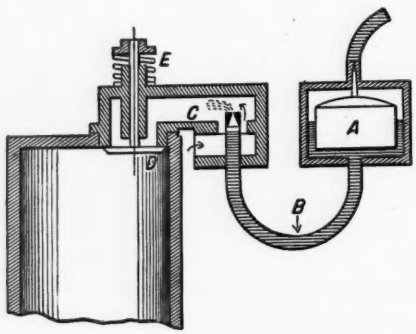


Fig. 6.—Section of Maybach Carbureter

Separate vaporizers as distinguished from carbureters are essential for kerosene and common for alcohol. They have been described at this point because the principles of their operation are simpler than those of carbureters and they are less numerous and less representative.

Carburetion is a process distinctly different from boiling. Air may take up the vapor of a liquid just as it takes up the vapor of water, even when the temperature of the liquid or the temperature of the air is very considerably less than the boiling point of the liquid. In short, air may take up some vapor at any temperature whatever, and it is not necessary that the liquid be brought to the boiling point. The amount of vapor which air can take up by simply coming in contact with the liquid depends upon the vapor tension of the liquid and the pressure of the air. The air may be assumed to be always at pressure, for the pressure in the suction pipe of an engine is but little less than that of the atmosphere. The amount of vapor that can be taken up from the liquid surface can be calculated quite exactly if the air is left in contact with the liquid long enough and if the liquid is a simple substance having a definite chemical composition and a definite vapor tension. The method is the same as that used to compute the humidity of the atmosphere. Since gasoline is not a simple substance, such a calculation is impossible, but it is known by the practical operation of engines having carbureters that at ordinary atmospheric temperatures the air is quite hot enough to vaporize enough gasoline to make a proper explosive mixture and is in fact capable of absorbing quite a considerable excess of gasoline before it becomes saturated with gasoline vapor. There is, however, no difficulty whatever from the standpoint of air saturation in giving to the air sufficient gasoline vapor to make a proper explosive mixture for engines if the air be left in contact with the gasoline long enough, or if, in addition, the contact be of the proper sort. As gasoline consists of substances of different volatility, the mere contact of the air with the surface of the liquid may not be sufficient to uniformly vaporize the mixture. The more volatile parts may come off first and there may be a residue which may be difficult to vaporize. This difficulty was met with in the earlier carbureters and overcome in a way that will be explained presently. Alcohol being a simple substance, with a definite vapor tension, it is possible to calculate at what temperature dry air must be to contain sufficient alcohol vapor. If the air has any temperature higher than this, it is capable of carrying more alcohol than is necessary for a proper explosive mixture or capable of absorbing the amount of vapor necessary in a shorter time.

By a somewhat lengthy calculation it may be shown that dry air at a temperature of 72° F., when saturated with alcohol vapor, has just enough of the vapor to form the theoretically best mixture for perfect combustion. If the air be moist, or the alcohol contain water, or the time allowed for vaporization be too brief, the temperature of the air must be higher than 72° F. to form a proper explosive mixture.

As the engine does not use pure alcohol of this sort, but rather mixtures known under the general name of denatured alcohol, the corresponding temperature necessary to secure this proper vaporization will be different from that just given, but just how different cannot be stated. However, it is certain that air at any temperature will take up some of the alcohol and that the higher the temperature of the air the quicker it will take up the necessary amount for the best explosive mixture. In the case of incomplete vaporization some of the fuel may be carried along as spray, which may be vaporized in the cylinder on the compression stroke or may not, but if not then it certainly will be after the explosion of the rest. It would seem desirable, therefore, to quite considerably heat the air supplied to an alcohol carbureter; yet indefinite heating of the air will bring about a bad effect on the engine, because it will make the charge hotter at the end of compression, or, in other words, decrease the weight of the charge in the cylinder. The horsepower of the engine, other things being equal, will be decreased in direct proportion as the density of the charge is lowered by this heating, so that, on the one hand, heating of the air is good for complete vaporization, but bad, if carried to excess, in reduction of power.

The earliest forms of carbureters operated on the principle of simple contact between the gasoline and air. One of the most successful of this type is that used by Gottlieb Daimler, to whom all credit should be given for the developing of this type of carbureter and by it the high-speed liquid-fuel engine. Daimler's surface-contact carbureter is shown in figure 5. It

consists of a tank fitted with a central tube and float. In the bottom of the tank is the gasoline, on its surface the float, and in the float a hole through which the gasoline may rise to a certain height. Air flows down a central pipe and strikes the surface of the gasoline at the top of the hole in the float, picking up vapor, the mixture flowing directly to the engine. The pipe down which the air flows is kept by the float to a constant amount of submersion, so that the air must bubble through the gasoline to a certain depth. The chief objections to this carbureter are found to be: (1) It would vaporize the most volatile part of the gasoline and leave the residue,

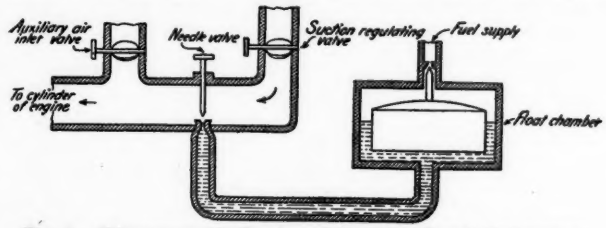


Fig. 7. Diagrammatic Section of Constant Level Carbureter with Needle Valve Adjustment

which is difficult to vaporize; (2) the slower the flow of the air through the carbureter the more vapor it takes up, so that at small engine loads or low speeds the mixtures were likely to be too rich if the adjustments were made for high speeds of the engine or rapid flow, and (3) the vaporization of the gasoline from the surface of the liquid cooled the liquid, because the latent heat of vaporization was largely absorbed from the liquid and the vaporization was slower as the liquid grew colder. In general this carbureter was incapable of maintaining a constant proportion of gasoline vapor to air at all rates of flow or at various temperatures of either air or gasoline and incapable of vaporizing all of the complex gasoline.

The first important improvement on this carbureter was made by Maybach, an engineer in the Daimler Works. This is shown diagrammatically in Fig. 6. Maybach's carbureter was designed primarily to make the apparatus independent of air temperature within a certain limit and independent of the rate of flow—that is to say, the speed and load of the engine—and likewise to prevent fractional distillation. The gasoline is delivered by gravity or pressure into the top of the chamber at the right through the opening, which is controlled by a needle valve attached to the float (A). As the float falls more liquid is admitted, which causes the float to rise, again decreasing the supply. The bottom of the float chamber is connected

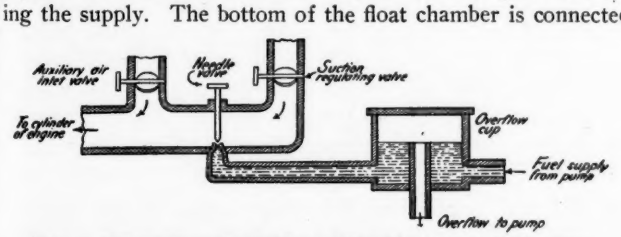


Fig. 8. Diagrammatic Section of Constant Level Carbureter with Overflow Cup

to the carbureter proper through the pipe (B). The air enters upon the aspirating stroke when the valve (D) is opened, whereby the pressure in the mixing chamber is made less than that of the atmosphere, so that the liquid fuel rises through the jet orifice by excess of pressure in the float chamber over the suction pipe and mixes with the air in the mixing chamber (C). It will be apparent that no valve is necessary except the one controlled by the float, and the fuel will only enter the mixing chamber (C) as required with the pressure variation on the suction stroke of the motor. The theory on which this type of carbureter was intended to maintain proportions was found in practice to be not quite true, although nearly enough so as to make it a great advance. It was expected that by reason of the partial vacuum in the air pipe surrounding the gasoline jet, due to the engine suction, it would lift from the jet a quantity of the gasoline proportional to the air. In other words, assuming a vacuum in the suction pipe, the quantity of the gasoline that would flow from the constant level chamber, under the influence of the vacuum, would increase in the same proportions as the quantity of air flowing from the atmosphere to the same vacuum. It was found that as the vacuum increased, owing to the speed of the engine and the load, more fuel passed over than was wanted, assuming that the carbureter was properly set for small rates of flow. This led to the introduction of another valve opening to the atmosphere between the carbureter proper and the suction valve of the engine. To facilitate adjustment of the vacuum another valve is inserted into the air pipe, entering the carbureter, and to facilitate initial adjustment of the mixture a sharp-pointed valve called a "needle valve" was inserted over the gasoline jet or nozzle. The arrangement of such a carbureter as this is shown in figure 7. The maintaining of a constant level just beneath the gasoline nozzle was found to be rather difficult if the float stuck or the float valve leaked. For this reason diaphragms have been tried as a substitute, but their use is still experimental. The carbureter is otherwise the same essentially as described above. When the engine to be used is not in boats or automobiles, subject to shocks and oscillations, but is at rest, the third arrangement (fig. 8) can be employed to keep the fuel level constant in the nozzle and to prevent flooding of the carbureter. A small chamber is fed by a pump attached to the engine and working with it. Gasoline is supplied much in excess of what the engine will burn, and the excess is allowed to run back to the tank through an overflow pipe. This overflow pipe fixes the level of the gasoline in the spray nozzle.

This arrangement is selected as a desirable one because it is effectual and because the fire underwriters' rules require that the gasoline tank be placed below the level of the engine to minimize danger by fire. In some of the latest types of carbureters the valve between the carbureter and the suction, which is intended to open at high speeds, is made automatic and opens by a spring. This has given rise to the name "automatic carbureter." In order to more intimately mix the spray with the air, various devices have been introduced above the spray, such as cones, plain and corrugated, pieces of wire gauze, at rest and spinning around under the influence of a fan driven around by the entering of the air. In technical language these devices are known as "pulverizers," but merely are nothing more than the means of breaking the gasoline into fine drops to permit of a more intimate mixing with air. It was supposed that the air would have sufficiently high temperature to absorb all the vapor that would be generated by the spray which was drawn into it, but in very cold weather, or on very moist days, it was found that at times the results were unsatisfactory. For this reason the air has been heated in

some forms of carbureters by simply drawing it on its way to the carbureter through a chamber surrounding the exhaust pipe. When the gasoline carbureters are used for alcohol a higher temperature for vaporization and carburetion is required. Thus heating becomes a necessity, and, not only is it desirable to extract heat from the exhaust pipe by drawing air from the surrounding chamber, but in some cases the mixture is also passed through a heated chamber so that no particles of residue can be unvaporized. In some forms of French carbureters the heat of the jacket water, which if it flows not too fast, has a high enough temperature, has been used for the purpose of heating the air, the liquid, or the mixture, to insure complete vaporization. But, as pointed out before, the alcohol will more or less vaporate at any temperature, and we have shown by our engine experiments that at ordinary temperatures, averaging about 60 to 80° F., enough alcohol can be vaporized to give a working mixture, although we also have evidence that all the alcohol does not vaporize, the remainder passing out as exhaust gases unburned or decomposed. The variation in important and unimportant details of construction in these carbureters intended either for kerosene, gasoline or alcohol is almost beyond belief. Practically everybody who has anything to do with these engines has designed a carbureter, and yet it can be proved beyond question that no carbureter on the market to-day, be it intended for any of the fuels named, is capable for carrying out that for which it is designed. While some vaporizers and carbureters to some extent will maintain the mixture perfectly well for some rate of flow or some particular temperature, no carbureter that has ever come to our attention will maintain an absolutely correct mixture for high speed or low speed, cold or hot air, moist or dry air, or changes in the rate of supply or engine load that must be met with in practical engine operation.

CARE AND OPERATION OF ROTARY CONVERTERS

By Jacob Glogan.

In nearly all cities of this country alternating current is generated in the main power house of an electric railway system on account of the low cost of transmission, and as nearly all the railways use 550 volts direct current on the cars, it brings into use a machine known as a rotary converter. A rotary converter is, therefore, the connecting link between alternating current and direct current systems. It combines in the armature and field windings practically two machines, an alternating-current motor driving a direct-current generator, or *vice versa*.

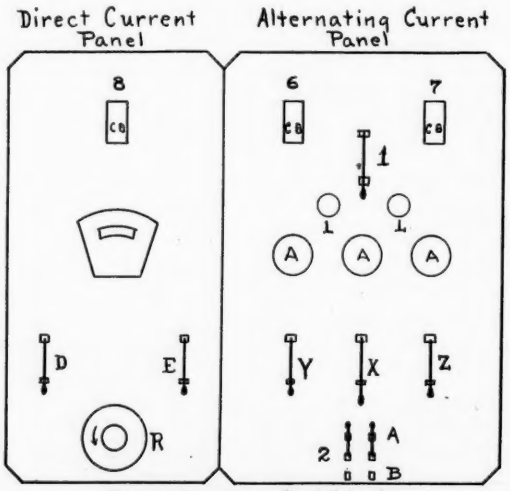
A rotary converter has the same appearance and is constructed nearly the same as a direct-current generator, with the exception of the collector rings, which are connected at different points of the armature according to the phase relations. Rotary converters are built for single, two, three and six-phase circuits, the two-phase machines being provided with four collector rings, and the three-phase machines with three collector rings on the Westinghouse machine and six collector rings on the General Electric machines. The fields of the rotary are sometimes separately excited, but generally they are self-exciting, and in railway work the windings are compound, so as to maintain a steady voltage at variable loads.

The ratio between the alternating and direct current voltages depends upon four factors: number of phases, wave forms, lead given to direct-current brushes and to the field excitation. With the alternating current having a sine wave, the ratio for two-phase is .71 and for three-phase .61; that is to say, if the direct-current voltage is 600 volts on a two-phase machine, the current to be supplied to the alternating current side will be

$$600 \times .71 = 426 \text{ volts};$$

$$\text{if 3-phase, } 600 \times .61 = 366 \text{ volts.}$$

Fig. 1 shows the arrangement of a generator panel in the sub-stations of the Metropolitan Street Railway of New York, where I have been associated with Westinghouse Rotary Converters, and the following method illustrates how these machines were synchronized and thrown on the circuit: Close single pole switch No. 1; this operates the oil switch, thereby bringing 300 volts alternating current to the board. Then throw in the induction motor switch No. 2 to the A position or starting position. The converter now begins to revolve and in about one or two minutes throw over to position B; this brings the converter up to approximate speed. We then build up the machine by moving rheostat R about half-way around and throw in circuit breakers No. 6 and No. 7. The neutral alternating current switch X is then closed and the synchronizing lamps LL are watched as they gradually die away, making sure that they do not flash bright again. Close switches Y and Z quickly, and after that the rest is very simple. We now build up the machine to line voltage and then throw in circuit breaker No. 8 and close switches D and E. The rheostat is then regulated so that the machine takes care of the load, which is found by examining the direct current ammeter.



Rotary Converter Switchboard

When the machine is taken off the line the same operation is gone through with, only in the reverse order. First, we

lower the voltage of the machine by turning rheostat all out; pull out circuit breaker No. 8 and then pull out switches D and E. Now, insert all the resistance by means of rheostat; then pull out circuit breakers No. 6 and No. 7; then pull out neutral switch X; then switches Y and Z; take out all resistance and throw out the oil switch by pulling out switch No. 1.

When the machine is stopped it is advisable to clean the armature and go over all the brushes to see if they are in good condition. One of the very important points in the care of rotary converters is to see that no copper dust is found around the network of armature taps and collector rings. This point is very important to those who operate General Electric machines of the three-phase type. There are six collector rings which are mounted on a large number of insulators, and the copper dust which comes from the brushes on the alternating current side generally lodges in and around these insulators. If this is not cleaned out, trouble will ensue which may go so far as to cause bad grounds and short circuits, which are disastrous.

The following pointers wil be found to be valuable when caring for rotary converters:

1. Converters should be located in a dry place.
2. Converter frames should usually not be insulated from the ground.
3. Always see that the commutator oscillates; this will keep the commutator from wearing in one spot.
4. See that the brushes fit exactly to the commutator.
5. Lubricate the commutator and collector rings occasionally with dynamo oil or vaseline.
6. Sparking is caused by
   - (a) Brushes not set right.
   - (b) Commutator may be rough.
   - (c) Machine may be overloaded.
7. See that the oil rings revolve or move freely in the bearings.
8. The heating of the bearings may be due to
   - (a) Dirty oil.
   - (b) Rough bearing surface.
   - (c) Bent shaft.

ARITHMETIC FOR ENGINEERS

Weights and Measures

By E. S. Hawkins.

Part VI

It is not the intention here to take up in detail the manner of measuring different substances according to certain arbitrary scales, but to point out in general how measurements are made. For further information and tables of units in different systems, the reader must be referred to standard works in arithmetic. Measurement is a process of comparison and in any system there must be some unit with which the object or substance measured is compared. Thus, in saying that a certain distance is 100 miles, we perform a process of comparison in which the distance is compared with the known unit of one mile and found to be just 100 times as great as the unit. Similarly when a bin is said to contain 10 bushels of corn, this result is found by a process of comparison in which the total quantity is compared with the unit bushel. There are, as is well known, various systems of measurement, but in any case there is an arbitrary unit that forms the base of the system and from which all other units are derived.

In all civilized countries standard units of measurement are determined and defined by the government so that there will be a uniform system of weights and measures throughout a given country. Even to-day, however, in this twentieth century of boasted progress and industry, the princes of commerce and industry have not succeeded in securing a uniform system of measures for all countries. Thus it is apparent that we have progressed only part of the way from the bad conditions of early times toward an ideal condition of uniform weights and measures which throughout the world are needed to make the transactions of commerce capable of quick and easy performance. In early times almost every city and province had its own system of measures, and this of course led to confusion when parties from different localities endeavored to strike the bargain. Thus in olden times tokens were used and passed for certain values as determined by custom. Stones of a particular form or variety and other things difficult to get formed the currency of the country and were used as money is to-day. In the museums of Greece and the older civilized countries of southern Europe, one can see to-day the stones and chips of metal that formerly passed muster for money. Then again, it is not so long a call to the day when so many skins passed for a certain value in the trader's camp, the Indian knowing that a skin of a certain kind and size would always get so much firewater.

In colonial days, different states had different units of value so that a dollar, instead of being worth 100 cents in all parts of the country, was worth more or less according to the standards adopted by the different states. This one instance of variation in money values in the different sections is enough to show the almost endless amount of trouble and confusion that can be caused by variation in the standards of value in different parts of the same country. Travelers can, by much application to study of the units of value, become familiar with "pesos," "centimes," "reales," "reiis," "centavos" and "cents" to handle their money with reasonable certainty of getting its value in a certain purchase, but few of them have become reconciled to the necessity of carrying four or five kinds of money in their change purses at the same time.

Thus far efforts towards uniformity have been successful only in so far as individual countries are concerned, although the measures adopted in the United States and England are practically the same, having only minor differences that can be detected by no one other than the ultra-precise scientist seeking trouble.

It was not until the year 1834 that the United States government adopted a uniform system of weights and measures to be used in the custom houses and other branches of the general government. Since that time the standards adopted by the Federal government have been adopted by the different

states. Since, in any system of measurement, it is desirable to have an invariable unit on which to base the system, one was sought by the government in planning the system of weights of measures adopted, and since astronomers have proved that the diurnal revolutions of the earth are performed in equal periods of time, it was decided to adopt the *day* as the invariable standard unit. Having adopted the period of one rotation of the earth as the standard unit, a measure of the unit was sought that should in some manner be connected with extension, and in attaining his end the clock pendulum was used, it having been found that with a pendulum of a given length the number of vibrations is always the same for a given period of time. Thus the day and this principle of the vibrating pendulum being found, the determination of the different units of measurement was easily made.

Altogether there are seven different measures; namely, length, surface or area, solidity or capacity, weight or force of gravity, time, angles, and money values. The first three of these measures may be classified as measures of extension and measures of capacity. The standard unit for measures of extension, whether linear, superficial or solid, is the yard of three feet, or thirty-six inches, and is practically the same as the imperial yard of Great Britain. It is determined as follows: The rod of a pendulum vibrating seconds of mean time in the latitude of London in a vacuum and at the level of the sea is divided into 391,393 equal parts, and 360,000 of these parts taken together constitute a length of 36 inches, or one standard yard.

For handling all systems of measurement, nothing more than a knowledge of the four fundamental operations of arithmetic, together with some acquaintance with fractions, is necessary. Readers who have read the previous articles of this series will be familiar enough with these operations to do all calculation necessary for ordinary measurement. Having the necessary knowledge of arithmetic, the next step is to memorize thoroughly the tables of units that will be used in one's particular work. There are, of course, certain of these tables that are almost universally used in all walks of life, such for instance as that of linear measures, which no doubt is familiar as A, B, C to all readers of this article. Every one knows how many inches make a foot and how many feet make a yard, as well as the fact that 5½ yards make a rod and that 320 rods make a statute mile, and persons familiar with engineering work and the operations in machine shops are acquainted with the difficulty had in getting all measurements exactly uniform for similar pieces of apparatus.

In a given shop no two rules will be found exactly alike when careful measurement is made, although to the natural eye they may appear to be identically the same. Then again, the divisions, although uniform in so far as can be seen by the eye, are more or less varying, depending on the error in laying them off. Thus a piece of mechanism measured with opposite ends of the rule will give a different measurement in each case, and even in measuring with the same end of the rule there will be seen to be differences in different successive measurements of the same dimensions. In some kinds of work these discrepancies make little or no difference in the work, but where exactness is required the differences cannot be tolerated. It is well understood in manufacturing circles that men are not machines, and cannot turn out a product with the precision of a piece of mechanism. To get rid of this personal equation error as much as possible shops use gauges as standards, rules being used only for the preliminary measurements, the final test of accuracy in construction being made with the gauge. Thus all parts are of exactly the same dimensions, and any two parts taken from different machines may be used interchangeably.

In connection with the matter of linear measure, it is well to remember some of the main items, such as the fact that a mile contains 5,280 feet, and for convenience of reference it is well for the engineer to make a list of such measures as he uses frequently, such as the area of his cylinder and of the piston rod, as well as the circumference and area of the tubes in the boilers, such items as the number of foot-pounds to the horsepower, and the number of square feet of heating and grate surface to the boiler horsepower, the capacity of the injector, the rate of flow through the pipe when feeding the boiler, and in a word all little points of data and information that have to be used in calculations. It is discouraging to dig the same thing out of a book every time it is to be used. It is in the hand-book all right, but among a lot of other things, and when once dug out should be labeled for future use. Right here it may be well to point out that the habit of mathematics is one of the best that the engineer can form. Tabulated information is condensed, hence it can be handled quickly and easily and a lot of it digested at a single glance of the eye. Tables of data of all kinds, such as a list of firms making packings of the kind used or "don'ts for the engineer," should be made out and used. It is the mathematical and precise working mind that gets there every time.

Having mastered linear measure or the measure of straight line distances, one proceeds naturally to the table of square measure, and in doing this all that is necessary to remember is the fact that any given dimension in the table of linear measure multiplied by itself gives the corresponding unit in the table of square measure, thus 12 inches make one foot and 12 x 12 or 144 square inches make one square foot, and 3 feet make one yard, while 3 x 3 or 9 square feet make one square yard. Similarly 30¼ square yards make one square rod and 160 square rods make one square mile or 640 acres of land. After square measure comes cubic measure, or the measure of capacity or solid contents of a body, and for the table used in this case one simply multiplies the figures found in the square table by the corresponding figure in the linear table; thus we have 12 x 12 or 144 square inches from the square table, and multiplying this again by 12 we have $144 \times 12 = 1{,}728$ cubic inches, equal to one cubic foot, while $9 \times 3 = 27$ cubic feet in a cubic yard, and so on. It is convenient to know also that 40 cubic feet of round timber or 50 cubic feet of sawed timber equals one ton or a good team load, while 128 cubic feet equals one cord of wood.

It is well here to distinguish between measures of solidity or cubic contents as just described and measures of capacity. There are in the first place two classes of capacity measures, the one being for liquids and the other for dry substances, and the unit of the one being the gallon while that of the other is the bushel. Both of these units are arbitrary, the gallon containing 231 cubic inches and the bushel 2,150.4 cubic inches.

After measures of volume and capacity come measures of weight or the action of gravity, and for this there are a number

of different tables, but the only one that interests the engineer is the avoirdupois weight or that ordinarily used in commerce where 16 ounces make a pound, 100 pounds make one hundred weight and 2,000 pounds make a ton. In this connection it is well for the engineer to know that a bushel of coal weighs from 70 to 80 pounds, it being usually nearer the larger figure. Other measures of weight are Troy weight and the weight used by apothecaries, the former being used in weighing gold, silver and precious metals.

One of the most important measures of all for the engineer is that of time, and since the units are familiar to every one they need not be mentioned here. The engineer must keep tab on what his machinery is doing, and to do this he must be familiar with the different time units and the manner of using them for measuring the capacity of his machines and the output for a given time, as well as for many other purposes, as time spent in performing certain work, compensation due to employees about the plant and numberless other things in which the time element enters. After measurement of time comes the measurement of angles and money values. Angles are used to some extent by the engineer, but all that he needs to know is the fact that 360 degrees or four 90-degree quadrants make a circle. Angles are used principally in graphical diagrams and are measured by a protractor, the use of which is too simple to need explanation. As to money, this is what all of us are after, and fortunately most of us have handled enough of it to know how the scale of values runs.

Mention has already been made of the standard unit of linear measure adopted by the United States Government, and it is now well to mention the units of other kinds adopted at the same time. Thus the unit of liquid measure is the old English wine gallon of 231 cubic inches, which is equal to 8.33888 pounds avoirdupois of distilled water at its maximum density, or a temperature of 39.83 degrees F., the barometer standing at 30 inches. The unit of dry measure is the British Winchester bushel, which is 18.5 inches in diameter and 8 inches deep, containing as already mentioned 2,150.43 cubic inches, which is equivalent to 77.6274 pounds avoirdupois of distilled water at its maximum density. It will be noted that these measures of capacity are referred in each case to the weight of a given volume of water, and this is done because it has been found that distilled water cntaining no impurities always weighs the same for a given quantity when weighed at a given temperature in every case.

The Troy pound of the mint from which the other tables of weight measure are derived is the same as the imperial pound of Great Britain, and is determined as follows: A cubic inch of distilled water in a vacuum weighed by brass weights, also in a vacuum at a temperature of 62 degrees F., is equal to 252.458 grains, of which the standard Troy pound contains 6,750. The avoirdupois pound contains 7,000 Troy grains. After the adoption of the act for uniform standards of weights and measures by Congress, sample measures and weights were distributed to the various states, and thence to the counties, so that the use of the units would be made general as soon as possible. To-day the government has a bureau of standards where measuring devices may be measured up to see how they compare with the standards, and thus insure great accuracy where required. With the exception of the standard imperial gallon, which contains 277.274 cubic inches, and the standard bushel, which contains 2,218.192 cubic inches, the standards of measurement, weight and capacity are the same in England as in the United States.

French measures are made on an entirely different system from that used in England and the United States, this system being known as the metric system, formed upon a decimal scale with a uniform invariable standard adopted from nature and called a *meter*. This unit was determined by making an accurate survey of that part of the north and south meridian or celestial circle between Dunkirk and Barcelona, France, under the direction of the government, and from this measurement the exact length of a quadrant of the circle or the distance from the equator to the north pole was computed. The ten-millionth part of the arc was denominated a meter, and from this all standard units of measure and weight are derived. On account of its flexibility in use, scientists and others have long endeavored to have the metric system universally adopted for mathematical and scientific work, as well as for practical measurements in the shops and manufacturing plants of all countries. For calculations there is no objection to the use of the system, but the cost of changes necessary to introduce it in manufacturing plants has thus far been effectual in keeping the system out of the shops. If the metric system is ever taken up for practical work it will be a good many years hence and after a long struggle to overcome the prejudices and fixity of custom and the natural difficulties standing in the way.

Opening of the Engineering Societies Building.

With the dedication of the Engineers' Building, on April 16th, the United Engineers Society opened its new home on West Thirty-ninth Street, between Fifth and Sixth Avenues, New York. This is the Engineers' Club, for the erection of which Andrew Carnegie gave $1,500,000.

Rising thirteen stories high, with a frontage of 125 feet, the Engineers' Club is an imposing structure, overlooking Bryant Park and the New York Public Library. The construction is of steel, covered with two to four inches of porous terra cotta, and the columns are grounded with concrete. The floors are of six-inch hollow tile blocks, in segmental arch overlaid with five inches of concrete. The walls are furred with terra cotta blocks, to keep out damp and prevent the spreading of flames in case of an outside fire. Particular attention has been given to the fireproofing because of the valuable scientific records and the material which the building contains.

The idea which led to the erection of the Engineers' Club was to bring together the various engineering societies of the United States, where they would have a common meeting ground for annual conventions, scientific lectures and demonstration, and to provide quarters for the National Societies of Mechanical, Electrical and Mining Engineers, as well as for such associate societies as might require headquarters in New York. While each is to maintain its individual character, all are to unite to advance the engineering arts and sciences.

The feature of the building is the large auditorium capable of accommodating 1,000 persons. Another feature is the free public library on the top floor. Heretofore, owing to the headquarters of the various societies being scattered, there has been a great deal of duplication in these libraries. Under the new arrangement all have been brought together. This concentration has given the Engineers' Club the finest and most complete library of its kind in the United States.

PURCHASING SECOND-HAND STEAM ENGINES

By R. T. Strohm.

As a usual thing, suspicion attaches to second-hand articles and apparatus, and there is always a certain amount of hesitation on the part of the buyer about accepting the statement of the dealer. This applies just as aptly to second-hand steam engines as to any other class of machinery. When it can be done satisfactorily and economically, it is generally better to secure new apparatus from manufacturers of unquestioned reputation. But this is not always possible. There may be a lack of the necessary funds to buy a new engine; the need may be urgent, so that a new engine of the desired size and type cannot be secured in time; or the location of the plant may be such as to practically compel the purchase of a second-hand engine from a local dealer in machinery instead of sending to the builders for a new one.

The fact that a second-hand engine is on the market may be due to a variety of causes. It may be put up for sale because of the failure of its original owner, who, to realize a small portion of his investment in his unfortunate manufacturing venture, is forced to sell the equipment at a sacrifice. It may be a part of some industrial plant that has been dismantled to make room for more modern apparatus. It may be discarded to the second-hand dealer because it is no longer able to furnish the power required by a growing manufacturing business. Again, it may be that its rejection is due to breakage of some of its parts, the repair of which was considered too great by the original possessor, who thereupon grasped the opportunity to purchase a new engine. Or, the inefficiency of an engine, due either to inherent faults in design or construction, or to gradual deterioration by wear and tear, may be the reason of its being put up for sale. In any case, the buyer should make a very complete and thorough examination of the second-hand engine that he contemplates purchasing; or, if he is not competent to do so, he should obtain the services of an experienced engineer or machinist. If it is possible to trace the history of the engine, so as to determine the reason for its rejection by the original owner, the prospective buyer will know about where to look for defects. Otherwise he will be compelled to go over the engine in its entirety, discovering the flaws as he proceeds.

Assuming that the purchaser has found a second-hand engine of the proper type for his purposes, there are a number of details to which he should pay particular attention in his examination. It is safe to assume that the parts of an engine that are liable to show most plainly the marks of service or the lack of proper attention are those which are enclosed and not readily accessible. Foremost in importance among these are the cylinder and the valve or valves.

A little reasoning will show why this is the case. Lubricating devices frequently become inoperative because of forgetfulness on the part of the attendant, stoppage of the oil ducts or pipes, or damage to the device itself. The surface of the cylinder barrel and the valve seats and faces can be examined only by removing the cylinder head, the steam chest cover, and the valve, or the valve bonnets, and the valves in the case of the Corliss engine. Now, the failure of internal lubrication does not show its evil consequences at once, as is the case with external lubrication, so that the valve, valve seat and cylinder are liable to be badly scored before the oiling devices are set going again.

Hence, as these are places where faults are most apt to develop, they should be looked over at first. There is a still better reason, however. If the valve face, the valve seat, or the cylinder, or all three, are scored, leakage is bound to occur, and anyone who has figured it out is aware of the amount of steam that can be thrown to waste through a small leak. Steam leaks at these points could not be easily detected, as the steam would escape through the exhaust pipe.

First of all, then, the buyer should see to the condition of the cylinder and valves. If cutting and scoring has occurred, the marks will be plainly evident. Where the damage is very great, it will be necessary to have the cylinder rebored, and if that has already been done, it should be noticed whether sufficient metal thickness remains to permit another reboring without making an unduly weak cylinder.

The cylinder may cause leakage of steam past the piston even if it is not scored. Such will be the case if it is worn somewhat out of round, or oval, as the piston rings will not then be able to fit the barrel closely at all points of the stroke. Hence the bore should be calipered to determine how much, if any, the cylinder has been worn by the piston, and to determine further what amount of reboring will be required. A straight-edge should also be applied lengthwise of the cylinder at a number of points, since the wear may have taken place almost wholly near the middle of the stroke.

The straight-edge should also be applied to the valve seat and face, in the case of the flat slide valve. Where rotary valves are used it may be impossible to determine their tightness by inspection. If convenient, they may be tested by blocking the piston in position and turning steam into the steam chest.

After examining the interior of the cylinder the exterior should be given careful scrutiny. Cracked flanges are not uncommon, and should be watched for. The stud bolts in the cylinder flange should be examined, to see that none are damaged or broken off. The threads in both the studs and their nuts should be looked at carefully.

Usually a cylinder is fitted with drain pipes, and these, with the necessary valves, should be in place. If they are not, plain drain-cocks should be found screwed into the cylinder on the under side. Oftentimes, too, the cylinder is tapped and piped for the attachment of an indicator. If the piping is not in place with its necessary stop-cocks or valves, the holes tapped in the cylinder should be closed with plugs. All of these small fittings should be attached, but they are quite liable to be removed from, or broken off, the cylinder.

The precaution of examining the cylinder for cracks should be extended so as to take in all the cast parts of the engine, especially the frame. This latter is so vital a part that a break in it may render the whole engine useless by reason of throwing the parts out of alignment when under stress. The frame or bed-plate is commonly the dirtiest portion of the engine, being covered with accumulations of dust and oil that have

formed a coating which entirely hides the metal. This dirt should be scraped off to expose the iron surfaces, and even then a small hammer may be used to advantage to discover fractures by hitting the frame and observing the sound.

As being next in importance, the various rods and shafts about the engine should be thoroughly inspected. The piston rod and the valve stem should be examined closely, to discover whether they are scored. A scored rod means leakage of steam from the crank end of the cylinder and constant trouble with the packing in the stuffing-box. The rod should be true and straight, or it will cause undue wear and leakage. The same things are true of the valve stem.

The connecting rod should be free from cracks, twists or bends, and it should be examined for such defects. Especially is it wise to be on guard against deception if the connecting rod is painted or in any way covered so that the metal of the rod is not fully exposed, as any such coating would hide faults in the material, as well as the nature of the material itself.

The main shaft should not be neglected. Examination will reveal any flaws, either in the material or in the workmanship. Especial care should be taken to see that there are no cracks in the shaft, since the rapid alternation of bending stresses would tend to develop the fault further and might end in serious accident.

Next, all journals, pins and bearings should be inspected. The faults that are likely to be found in these parts of a second-hand engine are worn brasses, warped brasses, scored shafts or pins, pins out of round and loose pins. If the brasses are badly worn or have been warped by overheating, they will have to be replaced or refitted before the engine can be operated satisfactorily, and the cost of this repair should be considered. If pins or shafts are scored, they will need to be turned up smooth before being put into their bearings. The wrist-pin and the crank-pin are liable to wear out of round, and if they are fitted with new brasses, before they are trued up, trouble is certain to result. The crank-pin should be absolutely tight in the crank casting.

The eccentric, eccentric strap, valve rods and pins (in the case of a Corliss engine) should be gone over carefully to discover whether there are parts so badly worn or damaged as to require replacement. Particular attention should be paid to the governor and its connections, as the safety of the engine and its attendants depend thereon.

After the engine has been given a complete inspection, the cost of the repairs necessary to put it into proper condition should be estimated and this amount added to the price asked for the engine. If the total is very close to the cost of a new engine, it would be better to take the new one, unless there is instant demand for power, and the new one is not immediately available.

What Do We Know About Our Boilers?

By F. J. Doyle.

I was wondering the other day, as I stood in front of my boilers, how much engineers really know regarding the boilers they are operating. We hear a great deal about tensile strength, double-riveted joints, braces of such a size as to stand a certain strain, but what do we know regarding the material and construction of our boilers? We know that boiler plate is supposed to have from 55,000 to 60,000 pounds tensile strength and we know that it is not desirable to have a tensile strength above 65,000 pounds, as above that the plate will be harder and less ductile. We also know that the elastic limit of boiler plate should be between 30,000 and 33,000 pounds per square inch, and it should have an elongation of between 20 and 25 per cent., and sometimes more, according to the thickness of the plate. We are told that the plate should be free from blisters, laminations and blow-holes and that the construction should be of the best. How much of the above do we actually know about the boilers with which we are in such close touch every day?

When an engineer takes charge of a plant, he naturally gives the boiler an inspection the first chance he has, and although he may find them in good shape so far as appearance is concerned, he has no way of ascertaining anything about the workmanship put in their construction or the actual condition of the plate as regards the tensile strength, elasticity, etc. Whether crystalization of the plates, rivets and braces has taken place is something the engineer cannot know, except as a result of an investigation after a boiler explosion.

One would think that with all the dangers attached to steam generation, boiler manufacturers would insist upon the best of everything in the construction of their products. There are times, however, when the flanges are turned and the plates are bent at a temperature that is liable to result in defective work. The bending of steel plates requires skilled handling, as they become brittle at a temperature corresponding to a blue heat. If work is done on steel plates at a blue temperature, cracks are liable to occur.

Very often the holes in the plates are punched rather than drilled. The practice of punching is not so bad itself, if the holes are left small enough to allow for reaming. This is something that is not always done, and the boiler is made with strictly punched holes. Punching tears the fibres and weakens the plate, and is done because it is cheaper to punch the holes than to drill them. Another matter over which the engineer has no control is the use of the drift-pin in the construction of a boiler. When the boiler plates are assembled there are times when the holes do not line up, due to error in drilling or punching, as the case may be. According to the advice given in our text-books, the plates should be thrown away and cut down for smaller boilers, but the boilermaker does not see things in this light, and the plates are used and knocked into place with the aid of a drift pin. This distorts the holes, and when the rivets are headed over they cannot fill the holes as they should. Such plates will be the first to show signs of unequal strain and distress.

The rivets and the method of putting them in the holes are very important features in the construction of the seams. The rivets should have a tensile strength of 48,000 pounds for iron and 55,000 pounds for steel, and they should have a ductility to be bent cold around a bar of iron of the same diameter and bent double when hot without breaking. Whether the rivets in the boilers we are operating come up to this standard or not is uncertain.

Without doubt, boilers are made in a better manner now than formerly, due, perhaps, to the attitude of boiler insurance companies, to the State laws relating to boilers and to the growing tendency toward the use of high steam pressure. When the matter is summed up, there is very little we actually know regarding the plates and the construction of boilers which we operate.

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Lightning Arresters.

In connection with all high tension power transmissions, there is one factor that is of extreme importance and that is, the protection of the line and apparatus from lightning, from high frequency waves set up by sudden changes of load, and from static charges. Among the various devices used are the horn arrester, the water jet arrester, the grounded steel wire, etc., but they are all designed and used with the same object in view. The essential features of a protective apparatus are as follows: (1) They should discharge at a potential slightly higher than the system. (2) The ordinary working of the system should not be affected by the discharge. (3) The electric energy of the static disturbance should be dissipated as rapidly as possible. (4) The static waves should be prevented from developing high potential differences in generators, transformers and other apparatus.

At the present time, practice varies considerably as to what is considered the best method to meet the above conditions. While some engineers distinctly favor the grounded steel cable which runs parallel to the transmission line, other engineers consider them of doubtful utility as they claim it is ineffective against the classes of lightning strokes most to be feared. When used, however, it acts usually as an auxiliary to other lightning apparatus.

It is probable that such a wide difference of opinion is due to the various conditions met with in different parts of the country. For instance, lightning and static disturbances are practically unknown at high altitudes while lines running through valleys suffer severely. It appears that the best lightning protection, used in main generating stations, has been obtained by using high resistance arresters in combination with the spark gap, this series parallel arrangement, giving the discharge a straight path to ground or a split path through the arrester. In another column of this issue Mr. Pagano, who has had wide experience in high tension plants both in this country and abroad, describes under the title "High Tension Lightning Arresters" what seems to be a lightning arrester based upon the proper design.

With this type of apparatus, known as the Gola arrester, there is provision made for low resistance, non-inductive paths to the ground. This has always been considered to be the ideal toward which lightning arresters have been designed, and, if the report is true, this type of arrester seems to have never failed to respond to the purpose for which it was designed.

—o—

Engineering Mathematics

Many of the problems that arise in engineering can be so easily solved by the use of algebra that we often wonder why it is that so many engineers dislike the very name of the subject. Only recently a letter came in stating, "No algebra for mine; cut it out." The fact is, that elementary algebra is very much more easily understood than arithmetic, and it is a great mistake of our elementary educational institutions that they omit to teach the subject and its important applications. Even the high institutions of learning do not seem to have an adequate idea of why algebra is taught, and it is probably the mistaken methods of the teachers of this subject that have caused such a deep-rooted dislike for it among practical men.

The rock-bottom understanding of many of the more technical branches of engineering, which are so necessary in these days, can only be had by becoming familiar with the numberless equations which from time to time we are all compelled to use. Take the well-known horsepower formula, H. P. = PLAN ÷ 33,000; that is nothing more or less than an alebraic equation. There is nothing in arithmetic than can take the place of such a simple statement, and the particular feature which makes the manipulation of such a formula so valuable is the fact that if four of the five variables are known, the fifth can easily be found by transposition. Take, again, the more simple hydrostatic formula, $p = wh$; if the weight of a cubic unit of water is known, any relation between p and h can be found. With such relations fixed in one's mind, one could become stranded in a desert and yet be able to work out many of the problems which are constantly arising around a power plant.

It was this latter formula that has brought to our mind the fact that while many engineers condemn the use of algebra, they at the same time use it without knowing it. We have during the past few weeks received many letters in answer to an interesting question, "How high will the water be?" and in almost every case the writer used and manipulated algebraic formula in some way or other.

Many processes used in algebra are nothing more nor less than simplified arithemetic, and the engineer would do well to get acquainted with them and hold them tight. Algebra is the center around which all the other branches of mathematics revolve, and the proper understanding of it is just one step toward the better appreciation of many of the principles which are the staff of an engineering education.

Gas Engine Propulsion.

Much comment has been aroused by the recently reported declaration of a well known American engine and ship builder that it is now feasible to build a vessel which will cross the Atlantic in four days, driven at a speed of thirty knots by gas or internal combustion engines, instead of by the usual steam engine and boilers which devour coal in their furnaces so rapidly that it requires a small army of stokers to feed them. It is said that plans are already drawn for a craft of the destroyer type, and, should the experiment prove successful, it will be tried on larger steamships. The success of the internal combustion engine for this class of work is very much doubted, however, by many other naval experts who claim that it is not practical with ships that demand the enormous horse powers so prevalent these days.

If, however, it should be true that the kind of engine, now so largely in use in the speedy motor boats, can be developed on a large scale, the revolution in maritime propulsion would be very marked. The reciprocating engine has been replaced on some large ships by the turbine, but this type of prime mover affords little if any economy of fuel, even though it may possess all the other advantages which its champions claim for it.

The change to a motive power which would do away with the storage of vast quantities of coal, thereby lightening the dead weight which vessels have to carry, thus increasing their interior space available for other purposes, is an improvement which has long been looked forward to; but, if at the same time, it should also add from twenty to fifty per cent. to their speed, the change in marine propulsion would be almost as radical as that from sail to steam. It would not only facilitate commerce on the high seas, but it would materially alter the condition of naval operations and make the present warships almost useless against vessels of this newer type.

There are several reasons, from a stationary point of view, why the proposed scheme does not appear too feasible, among which may be mentioned the cost of fuel, the liability of a gas engine to get out of order, and the enormous units in which the engines must be built. While it is a well known fact that the thermal efficiency of a gas engine exceeds that of the steam engine, there are other more important features to be considered. The strongest advocates of the gas engine admit that the two inherent defects of the gas engine are its inability to handle overloads and the annoying small troubles incident to gas engine operation.

The possibilities which the gas engine seems to unfold along many lines of engineering are interesting, but the fact remains that however pretty and ingenious the theory, it is the practical realization that confronts the inventor, which must be demonstrated before it becomes a proved fact.

When an engine is overloaded it is useless to expect it to operate with economy, and the same will apply when the engine is too large to do the work, because the point of cut-off will come too late in the one case and too early in the other for the economical distribution of steam. If the cut-off occurs too early, there will be an increased loss from cylinder condensation, and if too late, the expansion of steam will not be carried out as far as it should be. It will be found that when an engine is running under these conditions, it is better, if possible, to change the steam pressure or the speed of the engine, so as to allow the cut-off to occur at a point where greater economy can be obtained.

The gases used in gas engines belong to the hydrocarbon group and are of three kinds. First, natural gas, taken from subterranean sources; second, producer gas, made by the distillation of solid fuel by heat; third, carbureted air, made by saturating atmospheric air with the volatile constituents of a liquid hydrocarbon such as gasoline, kerosene or alcohol.

Among the signs which denote the healthy working of a refrigerating plant, besides the fact that it is satisfactorily performing its proper refrigerating duty, are the vibration of the pointers of the pressure and vacuum gauges, which clearly mark every stroke of the piston, the frost on the exterior of the ammonia pipes and the difference in temperatures between the condenser and the cooling water and the refrigerating coils and the brine.

Generators of standard makes will operate successfully in parallel if frequency, voltage and phase are the same, providing that, in direct connected units, the uniformity of angular velocity of the engines is such that maximum deviation of the rotating part of the alternator from the position of uniform motion does not exceed 2½ electrical degrees, and that the engine governors operate satisfactorily and without hunting.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

New Haven Engineer Says the Answer to A. R. G.'s Problem is 22.905 Feet.

EDITOR THE PRACTICAL ENGINEER:

In answer to A. R. G.'s question, "How high will the water be?" I would like to submit the following:

When the tank and pipe are empty there is a pressure of air due to one atmosphere, or 14.7 pounds, surrounding both tank and pipe; therefore, there is inside the pipe the same pressure, viz., 14.7 pounds. Now if we increase the pressure on the pipe by the admission of water at the lower end, then we must compress the air in proportion to the amount of water introduced into the pipe. We have the original pressure, 14.7 pounds, and to this we add the 5 pounds gauge pressure, making a total of 19.7 pounds. By dividing 14.7 by 19.7, we have .746 as the percentage of the pipe in which there is air, and substracting .746 from 1.000 gives .254 as the percentage of the pipe having water in it, so that the height of water in the pipe when the gauge registers 5 pounds is $25 \times .254 = 6.35$ feet.

Having found the height of water in the pipe, the next thing is to find out how much higher the water must be in the tank, above the level of water in the pipe, to counterbalance the pressure in the pipe. From a table of water pressures, we find that to exert a pressure of one pound it requires a height of water of 2.311 feet so that $2.311 \times 5 = 11.555$ feet as the difference in level. As the level of the water in the pipe is $6.35 + 5 = 11.35$ feet above the bottom of the tank and since the level of the water in the tank is 11.555 feet above the level in the pipe, we have $11.35 + 11.555 = 22.905$ feet as the height of water in the tank when the gauge registers 5 pounds.

J. W.

New Haven, Conn.

Kentucky Engineers Give 26.87 Feet as the Answer to A. R. G.'s Problem.

EDITOR THE PRACTICAL ENGINEER:

Your correspondent, A. R. G., on page 29, casts a great reflection on our high school boys, for this town is full of boys who will find no trouble with this problem. One of our boys sends this answer: The tank 30 feet high has an open ended pipe extending down 25 feet from the top of the tank, the top of the pipe being closed, and a pressure gauge connected. Now, to find how high the water will stand in the tank to show 5 pounds gauge pressure, first find how high the water compresses the column of air in the pipe at 5 pounds pressure, the absolute pressure of the atmosphere being 14.7 pounds. When the gauge shows 5 pounds, the absolute pressure is 19.7 pounds. The volume being inversely proportioned to this pressure, the height corresponding to this pressure will be $14.7 \div 19.7 \times 25 = 18.65$ feet. The pipe will then be filled with 6.35 feet of water. The water must rise on the outside of the pipe high enough to make the inside level record 5 pounds pressure, or $5 \div .434 = 11.52$ feet. The water level from the bottom of the tank is $5 + 6.35 + 11.52 = 26.87$ feet, or 3.13 feet from the top.

Louisville, Ky. E. S. H.

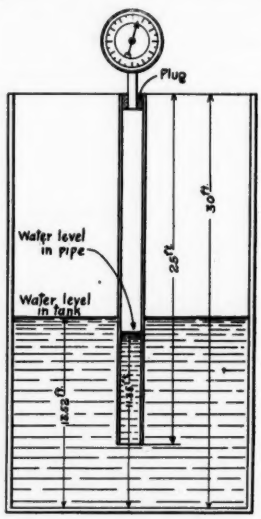
Answer to A. R. G.'s Question How High Will the Water Be?

EDITOR THE PRACTICAL ENGINEER:

In the April issue of THE PRACTICAL ENGINEER, on page 29, I not the query of A. R. G., of Middleboro, Mass., to which I would reply as follows:

There is a relation between pressure and volume of gases which finds expression in the equation $p\ v = p_1\ v_1$ in which $p\ v$ = pressure times volume in one instance, and $p_1\ v_1$ = pressure times volume in the second instance, the application of which may be applied to the problem in question.

The main features of the problem are these: The tank is *open* at the top, and it is 30 feet from top to bottom; but the pipe, which is referred to as being in the tank, is but 25 feet



Answer to A. R. G's Question "How high will the water be?"

in length; that is, it does not reach the bottom of the tank by 5 feet. This pipe is *closed* at the top, and *open* at the bottom. Let us assume that a pressure gauge is attached at the top of the pipe in communication with the interior of the pipe. The pressure which is to exist in the pipe, as recorded by the gauge, is to be 5 pounds per square inch; that is, the contained air in the pipe at first, is to be compressed by the rising water until a pressure of $14.7 + 5 = 19.7$ pounds absolute is shown, it being assumed that the atmospheric pressure is 14.7 pounds per square inch.

It will probably be understood that under the conditions named, there will be a difference between the level of the water in the pipe, and of that in the tank surrounding the pipe, because the pressure acting on the surface of the water in the tank is but 14.7 pounds absolute, or atmospheric pressure,

while the pressure acting on the surface in the pipe is 19.7 pounds, absolute as before shown.

Bearing the foregoing in mind, the problem may be solved like this: The water will rise in the tank to 5 feet before the end of the pipe is sealed and the contained air begins to be compressed. The respective heights in the problem may represent the respective volumes, as represented by v and v_1 in the equation. The pressure in the first instance is 14.7 pounds per square inch absolute, and the volume or representative height is 25 feet (not 30 feet, as some might infer at first thought). The pressure in the second instance is 19.7 pounds per square inch absolute, and it is required to find the corresponding volume or representative height. The statement is like this: $(14.7 \times 25) \div 19.7 = 18.65$ feet, which, in height, represents the volume of air above the surface of the water in the pipe. As the tank is 30 feet deep, $30 - 18.65 = 11.35$ feet, the distance from the bottom of the tank to the surface of the water in the pipe.

Now, in order for this level to be maintained against a gauge pressure of 5 pounds per square inch, or 19.7 pounds absolute, there must be a corresponding higher level *outside and surrounding* the pipe, in order to make a "head" to force the water up in the pipe. This head we find to be $5 \times .434 = 2.17$ feet. That is, the level of the water outside and around the pipe will be 2.17 feet higher than that in the pipe. The level of the water in the pipe was shown to be 11.35 feet from the bottom of the tank, so that $11.35 + 2.17 = 13.52$ feet, the level of the water in the tank from the bottom.

The accompanying sketch will materially aid the reader to a better understanding of the problem and method of solution.

Scranton, Pa. C. J. MASON.

Answers to A. R. G.'s Problem, 16.52 Feet.

EDITOR THE PRACTICAL ENGINEER:

With reference to the query of A. R. G in the April issue, I will state that in order to determine the height of water in the tank when the gauge registers 5 pounds, if we would divide *one* by the weight of a foot of water per square inch, and multiply by 5 registered on the gauge, and add the 5 feet of water in the bottom of the tank, the result would be 16.52 feet. That is $1 \div .434 = 2.304$ and $2.304 \times 5 = 11.52$, which added to 5 gives $11.52 + 5 = 16.52$ feet.

Rochester, N. Y. G. V. V.

This same answer was sent in by C. J. W. of Groton, Mass; J. C. S. of Cambridge, O.; G. H. C. of Detroit, Mich.; M. R. T. of San Francisco, Cal.; E. P., Cleveland, O.; A. J. A., Carneyville, Wyoming and J. N. V., Moyie, B. C.

Answers to A. R. G.'s Question and A. C.'s Governor Trouble.

EDITOR THE PRACTICAL ENGINEER:

I give herewith a solution of the tank problem submitted by A. R. G., on page 29 of the April issue. The weight of a column of water one inch square and one foot high is .434 pounds. Taking this as a basis, we have 5 pounds gauge pressure $\div$ $.434 = 11.52$ feet = the height of a column of water sufficient to cause a gauge pressure of 5 pounds. As the botton of the gauge pipe is 5 feet from the bottom of the tank, the total height of water in the tank would be $11.52 + 5 = 16.52$ feet.

The governor trouble of A. C., on the same page, could be caused by several conditions, none of which he furnishes, however. It would seem to me, in the first place, that 50 revolutions per minute, for an engine of that size, would be rather slow, and, with any fluctuations at all in the load, it would be very hard to govern and hold steady. Should the oil in the governor "gag" or dash pot be too heavy for these conditions, it would allow the engine to race before the governor could catch it, and would probably be equally slow in the other direction. I have seen an engine that operated on low pressure steam, through a pressure regulator, behave in just this way, because the regulator was working improperly and caused a fluctuating steam pressure. If the governor mechanism works hard at any point in its travel, it will cause these same fluctuations. If A. C. should find none of these conditions present on his engine, except the fact that the speed is slow, suppose he writes us again, and tells us the nature of the work done, the make of the engine and the style of the governor used, the boiler pressure, what kind of oil he uses in the gag pot and how full he keeps it, the kind and width of his main belt, and which way his engine runs, over or under.

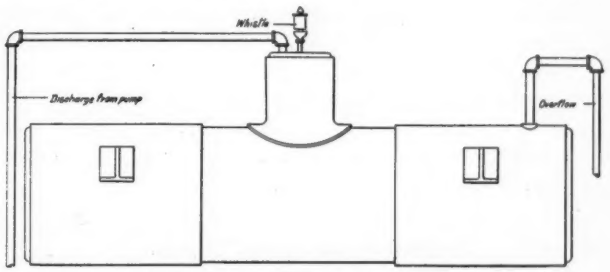
East Greenwich, R. I. L. L. ARNOLD.

Answers to A. R. G.'s Question. Home-Made High Water Alarm.

EDITOR THE PRACTICAL ENGINEER:

In replying to the question asked by A. R. G., in the April issue of THE PRACTICAL ENGINEER, I would state that the amount of water in the tank to show 5 pounds pressure would be $5 \div .434 = 11.5$ feet plus the 5 feet or 16.5 feet. Therefore, there would be 16.5 feet of water in the tank; the air in the pipe being balanced by the air acting on the surface of the water.

In the plant where I am employed as engineer, we have a whistle placed on the tank which acts on the same principle.



Home-Made High Water Alarm

The tank is an old boiler, with the overflow pipe the same height as the dome, as shown in sketch. When the water is the same height as the top of the boiler, the air in the dome is compressed by the water, thus causing the whistle to sound an alarm.

Barr's Mills, Ohio. M. S.

A. C.'s Governor Needs Overhauling.

EDITOR THE PRACTICAL ENGINEER:

In reference to A. C.'s governor trouble, I would say that it does not take much to cause a governor to fluctuate. I would, therefore, advise A. C. to pull it down and give it a good overhauling, and I have no doubt that he will find the trouble. Nine times out of ten the trouble is that the oil is not

reaching the spot it is intended for, and the only way to find it out is to take it apart and see if it is worn out or if it gets lubrication enough.

Winooski, Vt. M. M.

Heating Oil in Dash-Pot Will Cure A. C.'s Trouble.

EDITOR THE PRACTICAL ENGINEER:

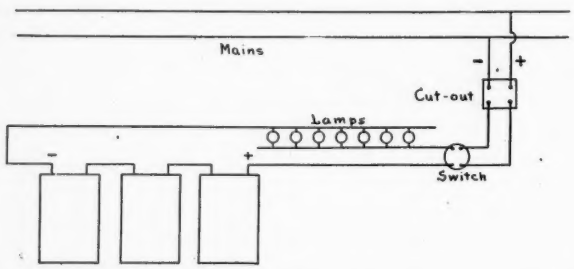
If A. C. would heat the oil in the dash-pot of his governor before he starts his engine, I think his governor would work all right. When the engine is not running the oil gets cold in the dash-pot and affects the governor. If this does not remedy the trouble, he had better change the oil in the dash-pot, because if the oil is not changed, in a while it gets stringy and makes the piston stick. F. J. D.

Benson, Minn.

Charging Small Storage Batteries.

EDITOR THE PRACTICAL ENGINEER:

As I have never seen anything in your journal on the charging of small storage batteries, such as is used in automobiles and for small electric motors, I will show a simple way of hitching them up with a 110-volt direct-current line.



Arrangement for Charging Small Storage Batteries

From the mains, the wires pass through a cut-out and then to a switch. A number of 16-candle power incandescent lamps are connected in parallel so that any amount of charging current can be obtained by inserting one or more lamps. If only ½ ampere is required, insert one lamp; if two amperes is required, insert four lamps, and so on. BERT.

Groton, Mass.

It takes Study to Get Theory.

EDITOR THE PRACTICAL ENGINEER:

I have read the article in the February issue of your valuable paper by S. T. and am of his way of thinking.

An engineer should be an engineer, not an oiler. He should be the man to expect good council and advice from. Can a man without some theory do this? A good engineer should be educated not only in the great school of experience, but in the "hows" and "whys" of doing things as well. This talk of too much theory is only caused by those who have none.

There seem to be plenty of engineers holding first-class licenses wherever licenses are required, and from those I know they seem to be satisfied with what they have been through to obtain them. It takes study to get this theory; that is probably the stumbling block of many.

In my present position of chief engineer, the rebuilding of our power house has been left almost entirely to me. I might add that I have never seen a college, in fact, nothing higher than a grammar school, but that is no sign that I have not studied.

More theory and less talk would be a good remedy for some of the kickers. W. B. M.

Kaukauna, Wis.

Drip Connections Again.

EDITOR THE PRACTICAL ENGINEER:

When Ericsson, of Monitor fame, was in charge of certain works in the vicinity of New York, he was very arbitrary in his management of certain matters, hence when the officials wished to experiment with new features on an engine they did not submit the matter to him, but secretly made a wooden model, and from this they had a working engine constructed. After steam had been turned on and the engine worked perfectly, they took the wooden model to Ericsson and asked him if such an engine would work if duly constructed. He proceeded to explain in detail how it could not possibly work, owing to inherent defects. They listened patiently until he had finished, then one of them said, "But it does work, Mr. Ericsson." "What do you mean?" said he. "We mean that an engine has been constructed from this model, and it is working perfectly." Mr. Ericsson took a few moments to consider what he had been told, then hurled the model to destruction against the wall of the room, saying with spirit, "Why didn't you say so before?"

Last summer I changed some of the connections in my plant so that they would work better, and after satisfying myself that an improvement had been made, I sent the matter in to you for publication, that others might receive the benefit of it.

One of your correspondents writes a letter stating his theory that it cannot work well in practice; but it did work, and has continued to give perfect satisfaction during severe weather up to the present time of writing, and anybody can examine it for themselves, if they doubt my statement.

Of what use is it for your correspondent to continue his statements that it will not work and cannot give satisfaction? I learned a long time ago that it is not wise to argue against a success, and am still further convinced that it is a waste of words. If I had advanced a theory concerning the way in which this work should be done, there would have been a chance for an argument; but under present conditions there is none, as I simply stated what I did, and that in practice it is successful.

On page 28 of the March issue, directly under the cut, there is a misrepresentation of what I have said in the matter as follows: "Mr. Wakeman says it will not work," but I have not made that statement, and none of your readers can point out where it can be found.

Your correspondent advanced a theory that my piping would not work well, and to this I replied that his theory concerning my work "don't work in practice," and it don't. See page 22 of the February issue. Furthermore, the theory that a heating system will not work well if there is steam in the return pipes, is all wrong and is unworthy of consideration.

In hundreds of plants, including one building in my plant, there are numerous connections from the main steam supply pipes directly into the returns; consequently there is nothing

to hinder steam from going into both main and return pipes. Steam does not circulate through a heating system in the same way that it passes from a boiler to an engine and through the exhaust pipe to the atmosphere, and it is not at all necessary that it should. If provision is made for allowing all water resulting from condensation to drain freely to a receiver of some kind, nothing else is necessary, as other steam goes to the radiators to replace it, and the rooms are heated. Nobody can tell whether all of this steam comes in through the main supply pipes, or if some of it comes up through the return pipes in which water runs along the bottom and finds its way to the receiver.

If anybody doubts the truth of this statement I will refer them to my plant, where much of the return system is heated before all of the radiators are. Furthermore, in my home all of the steam goes in through the return pipes, as there is no other way for it to get in (except in the case of one radiator), and it is true in every one-pipe system. If it will do this in a one-pipe system, it certainly will do the same thing in a two-pipe system, and there can be no objection to it, either.

If anybody imagines that this is a defect, let them put a good swing check valve in the return pipe at least one foot below the radiator, and that will prevent steam from going in through the return pipe.

New Haven, Conn. W. H. WAKEMAN.

Making Babbitt Hammers.

EDITOR THE PRACTICAL ENGINEER:

As every steam plant and machine shop should be equipped with a sufficient number of copper or babbitt hammers, the following is a description of the method I use in making babbitt hammers, which may be new to many engineers:

Procure a piece of 1½" pipe and cut off a short piece the desired length of the hammer. Dril a ⅝" hole central through both sides and cut the pipe through the center of the holes; file out the half circular holes to accommodate the handle and have the two parts turned to form a male and female joint, as shown in Fig. 1. Then cut a groove around the handle as shown at A-A, to hold it solid in the babbitt, and it is ready

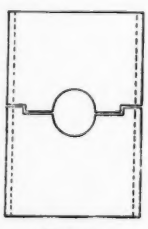


Fig. 1

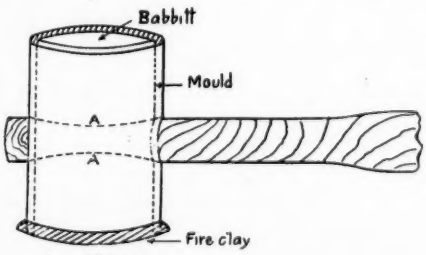


Fig. 2

to be put together as shown in Fig. 2. Before pouring the hot metal it is best to place the pipe on an anvil or piece of sheet iron, or any other smooth metallic surface. Place fire clay around the handle, and also around the bottom of the mould, as shown at B-B, Fig. 2. Care should be used in having the metal just hot enough to pour. When cold, remove the outside pieces of pipe, which may be easily done if sufficient care has been taken in filing them smooth inside, as the babbitt will not stick to a smooth surface.

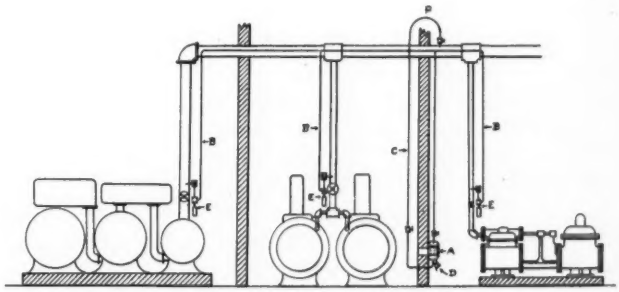
This makes a very satisfactory and inexpensive hammer, as the metal may be used over and over again.

Columbus, Ohio. M. B.

Lubricator Piping System.

EDITOR THE PRACTICAL ENGINEER:

For the benefit of brother engineers who have lubricator troubles, I would like to submit the enclosed sketch of lubricators and piping which we installed in our plant. We have one triple expansion Corliss pumping engine, 24⅛ x 36⅛ x 54 x 36, and one triple expansion Worthington pump, 10 x 33 x 58¼ x 36, besides two duplex boiler feed pumps, one con-



Piping System for Lubricators

denser pump, one suction pump, all of which have their cylinders lubricated in this way. As shown in sketch, A is the oil reservoir, B is the oil piping, C is the steam pipe to bottom of oil reservoir, D is the drip cock, E is the sight feed.

The steam pipe should have a loop in it to extend up 4 or 5 feet higher than the highest point in the oil pipe, as shown at P. The sight feed should be tapped in the steam pipe above the throttle, and the steam line to the oil reservoir must be tapped in the main steam lines to the boilers. The oil reservoir may be made from a piece of 6-inch pipe, a couple of feet long, with a cap screwed on each end and tapped for the connections, which are ½ inch in this case.

Laketon, Ind. F. R.

Special Licenses. Pump Troubles. Unsteady Engine.

EDITOR THE PRACTICAL ENGINEER:

In answer to the letter of C. T. P. about special licenses, I think his reply was a trifle strong to J. R. R.'s letter. His statement about the man holding the special license not being capable of handling a cook stove is a reflection on the examiner instead of the man, for I know of quite a few men that are running under specials and have been for years, and are perfectly satisfied, as they are not looking for a change, and I think they must be capable, for they seem to be running the same plant for years, and some plants between 1000 and 3000 horse power at that.

Now about the various pump troubles. I have been very much interested in them and I find a lot of boys who are doing quite a lot of guessing. I think I have had a lot of experience with independent pump troubles myself, but have always found that there is a cause for all of them, and what you would do in one case is no good for another; for instance, a water valve getting out of place, leaky pistons caused by springs getting loose, valve seats and valve stems getting shouldered and auxiliary pistons getting worn. All of these

things have caused me lots of trouble, but when I had a new auxiliary chamber, piston and new valve stem made, it remedied the troubles.

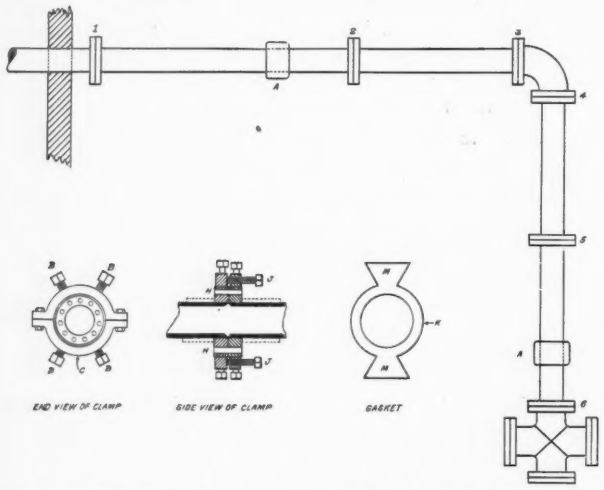
In answer to C. A. B. about his engine not running steady, I would say by all means look up the governor and connections to see that they are free in their movements and that they break connection proper from the cams; also run the oil out of the governor post where the mitre gears are and put in clean oil. If the governor has a dash pot, change the oil in that and use the thinnest oil possible. I use kerosene in mine and find that plenty heavy enough.

Fall River, Mass. H. M.

Putting Gaskets in Steam Line.

EDITOR THE PRACTICAL ENGINEER:

An engineer friend of mine invited me over to where he is employed recently, and while at his plant I saw a few things that perhaps may interest some of the vast number of readers of THE PRACTICAL ENGINEER. As I entered the engine room my friend greeted me with an oft-heard saying, "You're just in time to hear something new in the swearing line. I am going to put some new gaskets in the main steam line, and I know it's going to be a hard proposition, for whoever put the hangers on this steam line never intended that there should be more than the original set of gaskets put in between the flanges."



An Easy Method for Putting Gaskets in Steam Line

In the accompanying sketch is shown quite clearly a plan of the main steam line, joints 2, 3, 4, 5 and 6 of which were leaking quite badly, while joint 1 was being held with a clamp similar to C, as is shown in the end view of the sketch. I watched very closely every movement of the engineer, as he procured an extension ladder and placed it near the flanges at No. 2. He climbed up the ladder and began to measure the distance that the underside of the pipe was from the floor.

On questioning I found that he intended to shove up the pipe at each joint while he was taking it apart and putting it together. He was down off the ladder and in the act of cutting up a full length of 2-in. pipe, when I suggested that he could save that pipe for some other purpose and get the flanges apart much quicker and much easier, and when I mentioned the word *easier,* the engineer was attention at once. Pointing to the clamp on joint No. 1, I suggested that he take it off, and drill and tap two holes in each half of it for 5/8-in. cap screws similar to those shown at B B B B. These cap screws are made somewhat long so that they will take in the flanges 4, 5 and 6, which are somewhat smaller. A second clamp was procured from a flange joint on one of the boilers, and cap screws were fitted to it similar to the other one, and two cup screws were fitted through the sides of this clamp, as are shown in the side view at J and J. Both of these clamps were tightly secured, one to each flange, as is shown in the side view. Then the bolts were removed from the holes at H and H, and two bolts of the same diameter, but 2 inches longer than the old ones, were inserted in these holes. Then the other bolts were removed, and by slightly loosening the bolts at flange No. 6 the joints were separated something over an inch. The old gasket was removed, and a new one, 1/8 inch thick, similar to the one shown at K, was put in, with lugs M and M to enable the engineer to hold it in position while drawing up the nuts. These clamps and jack combination worked very nicely, and at the same time they were not injured in any way for their original application. After this work was completed I suggested to the engineer to put another hanger, similar to those at A and A, at or near flange number 4, which he did, and now often when I meet him he says, "Things are easy when you know how, are they not?"

Depew, N. Y. C. W. D.

The Use of Pulsometers and the Value of Fire Brick.

EDITOR THE PRACTICAL ENGINEER:

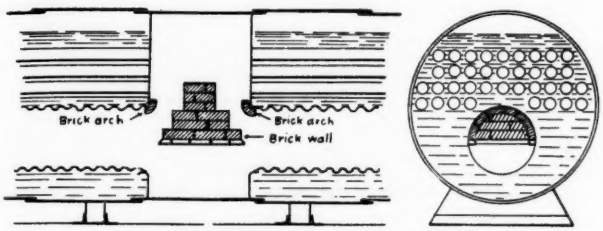
In the February issue of THE PRACTICAL ENGINEER, I read with many other interesting articles, your articles, "The Pulsometer Steam Pump" and "The Use of Fire-Brick Arches," and both, in my personal experience, have proven themselves friends in need when others failed.

One incident with the pulsometer pump came about when I was a junior engineer on one of the large Australian liners, which had the misfortune to turn turtle and sink while lying alongside the dock, causing the loss of ten or twelve lives. When all the openings, through which the water had entered the ship, had been closed as tight as possible under the circumstances by the marine divers, the largest centrifugal pumps to be had were started pumping water out of the hull to float it again. The water would be pumped down to a certain depth, when it would be necessary to stop in order to move the pumps to a lower depth to enable them to work at their full capacity, but as soon as two of the pumps were stopped the water would gain so rapidly that it was impossible to get them set in position before the water was up to its former height, which would submerge the pumps, and as they were direct connected to their engines this would put them entirely out of commission.

After trying different schemes for over two weeks and keeping us working night and day, it was almost decided to empty the lock dock and pump the hull out, which would entail a great expense and inconvenience to the rest of the shipping. Finally it was decided to try the pulsometer pump, and the result was that in less than five days the ship was afloat

and taken to the safety of the dry-dock. The pulsometers were slung in chains, and as the water was pumped out the pumps were lowered accordingly, steam being supplied by means of a flexible hose.

At another time I was on a different ship lying alongside Circular Quay, Sydney, N. S. W., when by the carelessness of



Fire Brick Arrangement for Preventing Leaks

the night engineer in taking off the bonnet of a sea suction, instead of a bilge suction, if it had not been for our two 6-inch pulsometer pumps we would have had another case of sinking alongside the dock. But by instantly starting our pulsometer pumps we held the water in check until we got our circulating pumps started and working on the bilge injections. By driving in a wooden plug which partly stopped the inrush of water and by keeping all the pumps in the ship working, we managed to keep the ship afloat, while the marine diver closed the inlet by placing a sheet of rubber over the grating on the outside, when we replaced the valve and bonnet.

My first experience with fire-brick arches was when I had just received my first appointment as chief engineer on a 5000 I. H. P. steamer. I was informed by the superintendent engineer that my predecessors had been having considerable trouble with the boilers leaking badly, but as the ship was going to be laid up and have an extensive overhaul as soon as the heavy passenger season was over, I was to do the best I could and not have any more work done on the boilers in foreign ports than was absolutely necessary. On taking charge I found that the ship had four double-ended Scotch marine boilers, which had a common combustion chamber for every two furnaces. I was told by my first assistant that all the trouble of leaking was confined to the bottom row of tubes and the back end of the furnaces, where the furnace was riveted to the tube sheet. On examination I found that the furnaces were not of the usual type, which have the saddle plate formed by being part of the furnace itself, but in this case the saddle was part of the tube sheet and was formed by the tube sheet being flanged inwards. This, in my opinion, was the original cause of the trouble, as the saddle was formed with too small a radius or too sharp a bend to allow for the unequal expansion and contraction which took place at that end of the furnace. However, let that be as it may, I found that in all the furnaces either the flange of the tube sheet which formed the saddle plate, or the furnace itself, were more or less cracked from the rivet holes to the edge. The bridge walls were too low to suit me and I had them raised to the height of the bottom row of tubes, to permit the cold air from striking the opposite tube sheet when either furnace door was open, and let it go at that. At the expense of a few wet shirts and a lot of strong language we managed to get to Hong Kong, where we had the worst of the rivets cut out and renewed and the cracks caulked. We started for home again, but before we got very far, eight of the twenty-four fires were out, as was the water, so we had to go back to Hong Kong and have some more rivets cut out and renewed. While the job was being done the Chinese gang foreman came to me and suggested the use of fire-brick as a remedy for the trouble. I told him to go ahead and get the fire-brick and we would try it.

When the riveting and caulking was finished the brick had arrived and was built around the end of each furnace, protecting the top of the furnace and tube sheet, as shown in the illustration. The result was that during the two years I was on that ship we never had our long-promised lay-up; neither did the thorough overhauling take place until two years after I had been transferred to a larger ship. The bricks were made specially for the job, and the only trouble we had when the arches were first installed was with the firemen knocking them down by their carelessness when slicing the fires; but they soon found out that it was better to be a little careful when slicing than to go into a hot furnace and rebuild arches at the first stop the ship made.

From that time on we would as soon think of going to sea without engine oil as to go without our arch bricks. All arches were taken down at each end of the voyage and the plate carefully examined, but from the day the arches were installed we were never troubled with leaky furnaces when lying under banked fires, as the brick retained the heat and prevented contraction. They did, however, cause a wonderful accumulation of ash on the face of the bridge wall, which formed into a solid hard mass, and if not kept from gathering by the use of the long slice bar, would eventually choke off the draught. But a little extra work with the slice bar was nothing in comparison to the troubles we had previous to using the arches and all hands in the engine room were more than pleased with the changed conditions.

From these experiences I have always had a great respect for the pulsometer pump and the fire-brick arch, and have given the fire-brick the credit of preventing sudden expansion and contraction, rather than being the cause of it.

San Francisco, Cal. SUB-MARINE.

Receiver Pressure for Compound Engines.

EDITOR THE PRACTICAL ENGINEER:

I notice in the March issue that the argument on the rule for finding the size of the cylinders for a 2000 horse-power engine is continued, and I should like to explain my reasons for figuring it as I did. I did not understand the original questions as purely theoretical, and outside of initial, terminal, and mean effective pressures, I tried to get as near to practice as possible.

From a purely theoretical standpoint, it makes no difference to the cut-off in the high-pressure cylinder where the cut-off is in the low, when the initial, back pressures, and load are the same on the engine. If the cut-off is short enough in the low-pressure cylinder so as to make the receiver pressure higher than the terminal pressure in the high-pressure cylinder, it does not change it; nor does it change it if it is lower; but when we come to practice, free expansion, cylinder condensation, etc., does make a difference, and the receiver pressure which makes the governor ride in the highest plane is certainly the most economical one. It seems to me that the load should have to be very steady to determine which was

the best receiver pressure to use, and that a careful test would be necessary to determine it.

In regard to the rule I gave for determining the best receiver pressure, I did not mean to infer that it would apply in every case; but the engines which I am running have a fixed cut-off in the low pressure cylinder, and when running their rated capacity the receiver pressure is very near that which the rule would make it. It seems to me that the makers of engines should fix the cut-off in the low-pressure cylinder so as to give the best results at that load. M. H. H. has again submitted his solution of the problem, and I still disagree with him. He has no drop between the cylinders and ¼ cut-off in each.

In order to accomplish that, the cubical contents of the low pressure at cut-off must be equal to the cubical contents of the high pressure cylinder; if it is not, the receiver pressure will be higher than the terminal pressure of the high-pressure cylinder, and if it is more, the pressure will be less.

Therefore, with ¼ cut-off in both cylinders, and no drop between them, the low-pressure cylinder must have an area four times that of the high or twice its diameter, making his cylinders 32" and 64", and increasing his engine to 2600 horse power.

North Abington, Mass. R. D.

Receiver Pressure of Compound Engine.

EDITOR THE PRACTICAL ENGINEER:

In the March issue, T. S. mentions a condition of a cross-compound condensing engine, in which, when the load goes off, the receiver pressure goes up; and when the load goes on, the receiver pressure goes down. In regards to this condition, I would like to ask him if the knock-off blocks have been changed on his high-pressure cylinder so as to make the engine carry an overload, and if the lap on his steam valves has been reduced; if so, when the load went off, the governor would be working at the highest plane and still the steam valve would be open just enough to take some steam, whereas, when the governor was in that position, in order to be safe, the steam valve should not allow any steam to enter the cylinder. When the governor drops as it does when the load goes on, it allows steam to follow further in the low pressure cylinder which reduces the receiver pressure and also the speed of the engine as the governor drops to its working plane. A leaky piston on the high pressure cylinder, or leaky exhaust valves on the same cylinder would have a similar effect.

I would suggest carrying a receiver pressure low enough to carry the load nicely, by shortening the cut-off in the high pressure cylinder, so that when the load is thrown off, the governor will work in a lower plane than it does at present when load is thrown off.

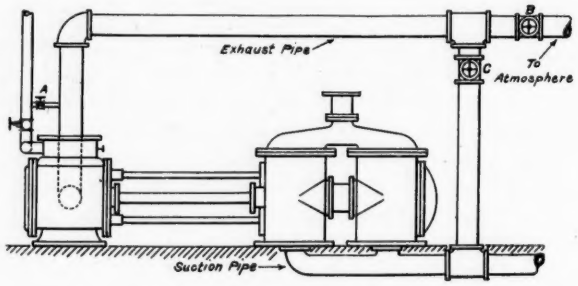
Fall River, Mass. M. H. H.

Peculiar Arrangement of Pump Exhaust Pipe.

EDITOR THE PRACTICAL ENGINEER:

While visiting an engineer friend in his engine room some time ago I noticed a peculiar arrangement of the exhaust pipe on his pump. This pump is of the double-acting duplex, outside packed plunger type. The steam cylinders are 24" x 38" and the plungers 9" x 38", with a lift of 13 feet, pumping against a head of 400 feet and running at the rate of 60 strokes per minute.

There was a tee placed in the suction pipe (as per illustration), 6 feet from the pump into which the exhaust pipe was connected. Before starting the pump the air is driven out of the exhaust and suction pipes by filling them with steam through the by-pass A, having valve B closed and valve C open. When all air has escaped valves A and C are closed, and valve B opened, condensation taking place there, creating a partial vacuum in the suction pipe. When the pump is



Peculiar Arrangement of Pump Exhaust Pipe

started it takes the water without any difficulty. After the pump has been running a short time, valve C is opened and valve B closed at the same time, which turns the exhaust into the suction pipe, thus acting as a condenser and increasing the speed of the pump 10 strokes per minute.

This arrangement has been in operation for several years and has always given satisfactory results.

Northampton, Pa. VISITOR.

Short-Stroking Pump.

EDITOR THE PRACTICAL ENGINEER:

On page 22 of the March issue of THE PRACTICAL ENGINEER, a writer, signing his letter H. M. C., claims that I have an entirely wrong idea about the extra stuffing box put on the valve rod of a Deane pump, and explains his reasons as to the cause of the pump short-stroking. As my experience does not agree with his statement that the pump only short-strokes on one end, I will explain my reasons for my former statement.

The pump I have reference to is an independent condensing pump, and I have seen it short-stroke on one end, slow down, or slacken speed, and then return to the other end and short-stroke again. If it were the unbalanced end of the valve rod that caused it to short-stroke on one end, as H. M. C. says, what caused it to short-stroke on the other end?

In starting this pump in the morning, after getting it going nicely, I give the pump a good dose of oil, and sometimes it would cause the pump to immediately short-stroke, and the same thing would happen at night just before shutting down, and all I had to do was to turn the nuts on the stuffing box bolts one-half turn and the pump was O. K. again. Sometimes the pump will short-stroke on either end, and it will keep short-stroking until it stops, or until the gland on the valve rod is set up. On page 20 of the December issue, H. M. C. will see that this writer claims that it is the friction of the tappet arm on the valve rod that causes it to shift the auxiliary valve before the tappets are struck. The pump to which I refer has the tappet-block sliding on the valve stem, with piston rod arm and link attachment.

Fall River, Mass. M. H. H.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Hydraulic Ram Problem.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer for me through the columns of your paper at your earliest convenience, the following questions?

The farm on which I live has a lake on it about 400 feet from the house and the bottom of the lake is about 15 feet below the ground that the house stands on. I wish to force a 2 inch stream of water from the lake over the top of a 16 foot tank located at the house, with a hydraulic ram. What depth should the pit be in which the ram is located, below the bottom of the lake, and what size ram would I be required to use? To furnish the 2 inch discharge, what size supply pipe to the ram should I use, pipes to run in and out of the pit on an incline? The entire raise will be 30 feet, and the lake is from 1 to 2 feet deep and covers 60 acres. I have a 5,500 gallon tank and wish to use the water for irrigation.

Paradise, Texas. L. B.

A 12-inch ram will be required 12 feet below the bottom of the lake. The supply pipe should be 4 inches diameter, supplying 144 cubic feet per minute to the ram. This will discharge 12½ cubic feet per minute at a height of 30 feet.

Lacing Belts.

EDITOR THE PRACTICAL ENGINEER:

Will you tell me which is the quickest and best way to lace a belt, and also how tight a belt should be on a pulley wheel?

Slidell, Fla. G. O. F.

Just what method would be the quickest and best to use would depend upon the purpose for which the belt is to be used. Efficiency and durability of the joint, however, should come before ease of lacing. Of the various methods in use, that

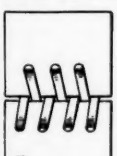


Fig. 1

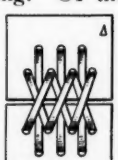


Fig. 2

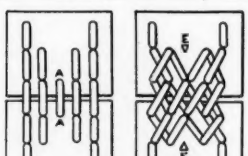


Fig. 3

shown in Fig. 1 represents the hinge joint, which is used chiefly for running small wheels at a high rate of speed and can be made very quickly. The lacing is inserted at one side of the belt, and, after passing through the hole, is dropped down between the ends of the belting and is brought up on the other side in the opposite hole. This is repeated, until the width of the lace is finished. An easy joint to make for heavy work is shown in Fig. 2. The first operation consists in squaring off the ends of the belt. The holes are made opposite each other, the outside holes being laced first and then the inside holes. Fig. 3 represents another lace joint; the straight lacing should run next the pulley, while the crossed part represents the outside of the belt. The lace is begun at *a, a* and laced each way and return, ending at *e, e*, on outside of belt. Fig. 4 is somewhat similar except that the lace is started on one side at *a, a*, and laced across, the belt and back, ending at *e, e*, on opposite

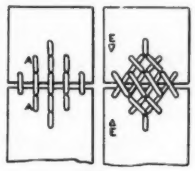


Fig. 4

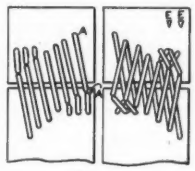


Fig. 5

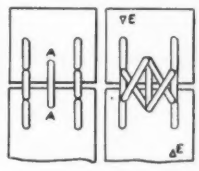


Fig. 6

side of the belt. Fig. 5 represents a belt lacing for quarter-twist belts. It is started at *a, a* and ended at *e, e*, the parallel laces, as usual, being on the inside, and the crossed lacing on the outside. For narrow belts the lacing shown in Fig. 6 will be found satisfactory. Commencing at *a, a*, on the outside of the belt, it is laced each way, ending at *e, e*, on opposite side of belt.

The belt should not be any tighter than necessary, so that it will transmit the work without slipping. The best way to determine the proper tension is by experiment and observation.—

Size Pump for Boiler. Taking Cards on Compound Engines.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly publish in your very valuable and instructive paper the rule for finding the size pump for any boiler; also the method of setting the valves of a compound condensing engine; also the method of taking indicator cards from a compound condensing engine? Is it necessary to use two indicators, one on each cylinder and should any precau-

tions be taken when taking cards from the low pressure cylinder in regards to losing the vacuum?

Brooklyn, N. Y. H. C.

The best method would probably be to find the amount of water required by the boiler or boilers per hour; then look up in a catalogue of the pump manufacturer and pick out the type of pump which will give the required duty. For instance, suppose the boiler under consideration has a nominal rating of 100 horse power. Allowing for an overload of 25 per cent. and assuming that the boiler evaporates about 30 pounds of water per horse power per hour, the number of pounds of water required per hour will be 3750 pounds or 450 gallons. If a duplex pump is required and it is assumed that each piston makes 100 strokes per minute, then a 3" x 2" x 3" duplex pump would answer the requirements.

The valves of a compound engine are set in the same manner as those having only one cylinder, the object being to attain the proper steam distribution so that both cylinders will either generate the same horse power or have the same range of temperature. This can only be found by the proper use of the indicator by means of which the exact points of cut-off, release, compression and admission in each cylinder can be obtained.

When indicating a compound engine and when extreme

accuracy is required, four indicators should be used, two on each cylinder; but for the purpose of setting valves, two indicators are sufficient, one on each cylinder. When taking cards on the low pressure cylinder, the principal precautions which should be taken are to see that the atmospheric line on the card comes a distance above the lower edge sufficient to register the vacuum which of course comes below the atmospheric line, and also to be sure that the indicator cocks are in good condition and do not leak.

Setting Valves of the McIntosh and Seymour Engines.

EDITOR THE PRACTICAL ENGINEER:

Will you please give, through your valuable paper, instructions for setting the grid-iron valves of the McIntosh and Seymour engines? C. M. G.

Northampton, Pa.

The valve gear employed on this type of engine is simply

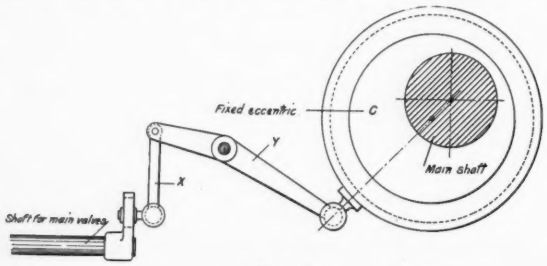


Fig. 1

an arrangement of links, rock-shafts and slides for transmitting the motion of the eccentrics to the valves. The main valves are driven by a fixed eccentric controlling the admission of the steam and the opening and closing of the exhaust. Any one of the four operations of admission, cut-off, release and compression can be varied independently of the others by adjustment of the gear. The valves of this engine are of the multi-ported flat gridiron type, located at each of the four corners of the cylinder. There are two main steam valves and two main exhaust valves, in addition to which there are two riding cut-off or auxiliary valves placed on top of the main steam valves.

In practice, the main steam valve is set to close when about 60 per cent. or more of the stroke has been completed, so that steam may be carried up to this point unless cut off earlier by the auxiliary valve. The governor operates only these auxiliary valves. This is done by means of a rock-shaft, which is connected to the governor eccentric and which operates the links. The governor eccentric is arranged to revolve around

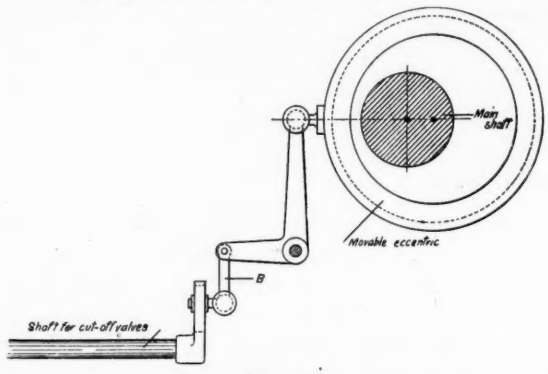


Fig. 2

the shaft by the action of the governor, and governs by varying the angle of advance, the movement of the two valves being such that the cut-off valve is moving in an opposite direction to the main valve when cut-off takes place. As the valves are multi-ported, only a small movement is required to give full port opening.

When setting the valves, it is necessary to know the strokes, laps and leads of all the valves, the points of cut-off for both the main and auxiliary valves and the point of exhaust closure or compression. These can generally be obtained from the makers who keep a record of all engines built. Having these figures, the first operation is to set both the main steam and exhaust valves.

First, turn the engine over slowly and by means of link X connecting rocker arm Y and shaft S, Fig. 1, adjust the angular movement of shaft S until the exhaust valve shows the proper travel. As soon as the proper stroke is obtained

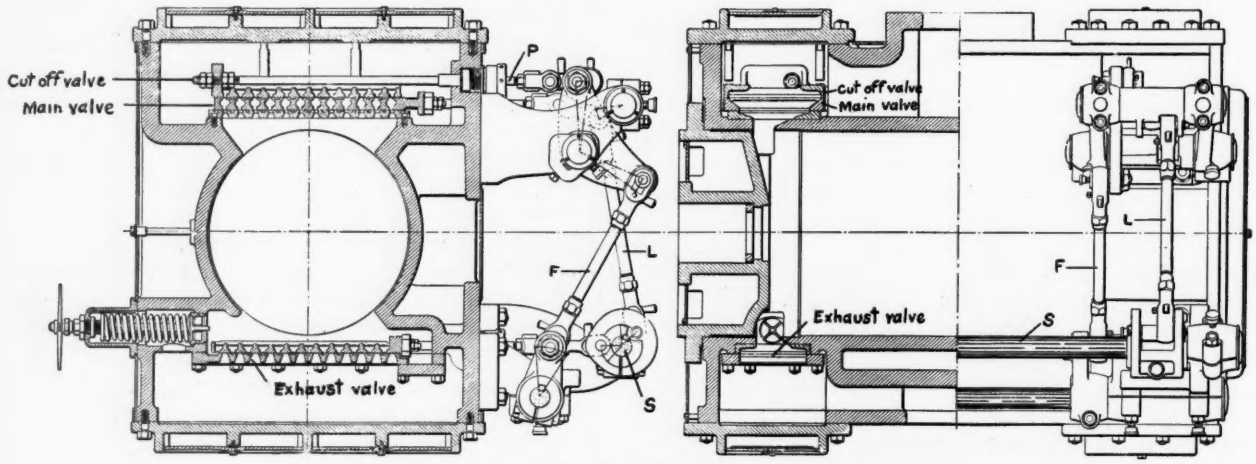


Fig. 3. Cylinder and Gridiron Valves of the McIntosh & Seymour Engine

set up the lock nuts on link X and by means of link L, Fig. 3, adjust the stroke of the main steam valves. Having removed the valve covers, the proper lead and lap of the valve should be found. This can be done by screwing the valves in or out of the small crosshead P, Fig. 3. With the engine on the head-

end dead center, roll the fixed eccentric, C, Fig. 1, around the shaft until the head-end main steam valve shows the proper lead, or is "line and line" if there is no lead. Then lock the eccentric in place with the set screws.

Next lay off marks on the guides corresponding to the head-end center crank-end center, cut-off of auxiliary valve, cut-off of main valve and point of compression for both ends. When the engine is placed on the forward stroke so that the cross-head mark corresponds to the point of compression for that end, the crank end exhaust valve should come line in line. Place the crank on the head-end dead center and move the crosshead until the mark on it corresponds to the point of compression for the head end when the head end exhaust valve should come line in line. Then place the crosshead so that the mark on it will come opposite the points on the guide where the main valve should cut-off, in which case the main valves should come line and line when the crosshead has arrived at those points.

To find exactly when the valves are line in line, reference can be made to marks which are placed on all main steam and exhaust valve stems. These marks encircle the stem, and, by means of a tram of known length, the exact position of the valve can be found by reference to this mark, using some point on the cylinder casing as a fixed point. By this means, it is necessary to remove the valve covers every time the valves are set.

To set the auxiliary or cut-off valves, measure from the dead centers, and locate on the crosshead guide the point of cut-off of the auxiliary valves as furnished by the builders. Adjust link F, Fig. 3, and link B, Fig. 2, to give the proper stroke of the valve, measuring the stroke by the movement of the mark on the stem. Then turn the engine forward until the crosshead mark corresponds to the point of the auxiliary valve cut-off and set the head end auxiliary valve line and line with the port of the main valve. Set the engine on the other stroke, and, when in the proper position, set the crank end auxiliary valve. In all these operations, the governor should remain closed.

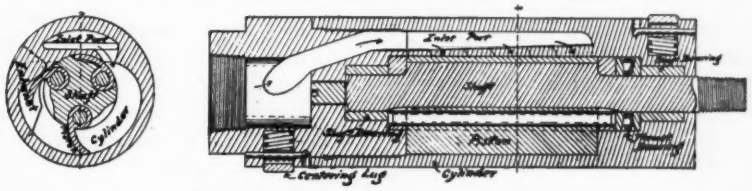
When getting the proper setting, which applies in general to all valve gears, all the bearings, rockers, etc., should be free from unnecessary lost motion, and, when placing the engine on dead centers and in turning it over to obtain the several points in the stroke, it is equally necessary to take up all lost motion in the direction of rotation. That is, should you run past a mark, do not bring the engine back to the mark, but considerably further than the mark, and bring the engine up to the mark again in the same direction that the engine is to run when turning under the influence of steam pressure.

Front view of " Demon " in tube, showing how the " Demon " cutter head entirely fills the tube.

The Demon Boiler Cleaner for Straight and Curved Tubes.

The constantly increasing number of power plants that are being equipped with water-tube boilers has made the cleaning of this type of boiler a very live question. For a long time after the introduction of these boilers, the only tool on the market for cleaning them consisted of a small turbine wheel and casing, directly connected to the hose which furnished a supply of water under pressure for operating it. The actual cleaning device or scale remover was attached to the forwardly projecting end of the shaft of the turbine wheel and consisted of one or more freely swinging arms with small tooth disks rotatively mounted thereon. These two disks were intended to be held in contact with the scale by the centrifugal force resulting from the rotation of the head. There was thus nothing positive as to the amount of scale this cleaning device would remove, and the operator could naturally, therefore, feed the tool forward just as soon as a big enough hole had been worn in the scale to permit the body of the motor to pass through it.

The accompanying illustrations represent the "Demon' water-tube boiler cleaner, which has overcome these difficulties and which embodies all the latest improvements. It is so constructed that the cutter-head entirely fills the tube, and as it is non-yielding the operator cannot help but clean the tube perfectly. It will be noticed that the barrel or motor body of the cleaner is provided with a longitudinal inlet port, which is in free communication at its rear end with the water supply line, and at the other end with the cylinder.



Sectional Views showing construction of " Demon " Cleaner

Having entered the cylinder of the cleaner, the water transmits the full force of its pressure to the whole area of one of the three folding pistons with which the shaft is provided. The opening of the inlet port into the cylinder directs the flow of the water in such a way that when the free end of any of the pistons passes by the latter will at once be fully opened and projects across the cylinder space. The pistons are, moreover, so arranged on the shaft that this always takes place before the next preceding piston has reached the exhaust, so that one piston is always in working position. The motor has no dead center.

The torque or twisting power in this motor can be very great, as it is only necessary to use a piston of large area. With the "Demon" form of motor, the diameter of the tube does not limit the power of the motor, but on the contrary, the pistons being arranged lengthwise and parallel with the tube, the length of the tube can be taken advantage of. The entire construction is such that not only is a very powerful motor developed, but the design of the machine is such that large parts with ample wearing surfaces can be used, and the whole motor made of substantial construction. It is said that in a comparative test between a 4" motor of the "Demon" type

and the same size cleaner of other types, the "Demon" developed over forty times the turning or twisting power so essential in the thorough and rapid removal of boiler scale.

Advantage has also been taken of the long barrel of the "Demon" motor to attach to it a front and a rear set of centering lugs by which the cutter-head is always held in central alignment with the tube.

The " Demon " Cleaner for Curved Tubes

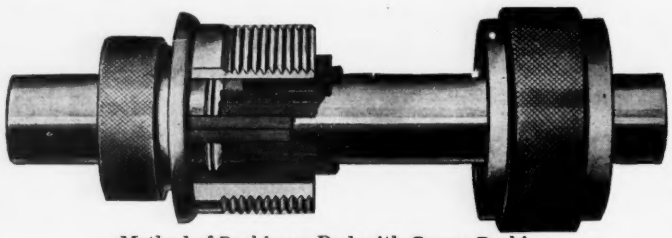
The small cut illustrates the "Demon" modified for use in curved tube boilers. All the essential features of the "Demon" motor have been retained, with the exception of the centering device, and a further modification in introducing the flexible connection between the cutter-head and the motor. This, in connection with the shortness of the body of the cleaner, tapering at either end, readily permits the cleaner to follow the sharpest bends commonly found in the curved tube boiler.

It has been found that pistons of sufficient area can be used in this form of cleaner, with the result that a motor of a high power is developed, and very high speed is maintained. As a result of the surplus power in this form of motor, the speed of the machine is not perceptibly reduced, even when confined within the tube limits, and operating against a heavy load in the nature of hard, heavy scale. These machines are owned and manufactured by the General Specialty Co., 893 Niagara Street, Buffalo, N. Y.

Cassco Bar-Metallic Packing.

A new form of packing, which is being placed before the engineers, embodies the advantages of both the plastic and metallic types of packing. It is made in plastic bars, each bar being six inches in length and varying in thickness from one inch to one-fourth of an inch.

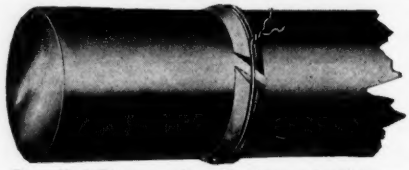
When packing a rod, as shown in illustration, the plastic bars are placed in the stuffing box endwise, using as many as are necesary to go around the rod. When the box is full, screw up the gland hard, which compresses the packing in a solid ring. The box must be full of packing, the gland



Method of Packing a Rod with Cassco Packing

screwed very tight and the pressure continued until the packing sets, after which the pressure may be removed. The packing is always placed around the rod when it is warm, so that it can assume the shape of the interior of the box when it is being compressed. The packing, under running conditions, is never taken out, new packing being added from time to time.

To prevent any packing from working its way into the cylinder, should there be any space around the rod at the back of the stuffing box, a bevelled metallic ring is used. To fit the ring in place, cut a piece of the ring metal to fit the rod with the ends bevelled. Bend the ring metal around the rod, with



Bevelled Ring used with Cassco Packing

the short bevel toward the back of the stuffing box. Place a piece of copper wire in the groove, as shown in the accompanying illustration, and by twisting the ends of the wire together, draw the ring up tightly around the rod. Push the ring to the back of the stuffing box and pack as usual.

The Cassco packing has its principal applications on piston rods, valve stems, expansion joints, air compressors and pumps, and can be used for steam, ammonia, oil and gas. The Cassco Bar-Metallic Packing Co., 140 Dearborn Street, Chicago, Ill., are the manufacturers.

Economy in Using "Renewed" Incandescent Lamps.

It is general practice among all electric lighting companies and large consumers of incandescent lamps to have their lamps renewed when the carbon filament burns out, because it would be just as extravagant to throw away a kerosene lamp when the wick has burned out as to discard the incandescent lamp when the filament is broken.

When a lamp has the base, bulb and platinum leads in perfect condition it is a comparatively inexpensive matter to mount a new filament in the bulb, exhaust the air and seal the top, when the lamp is equally as good as when it was first purchased. The Boston Incandescent Lamp Co., of Danvers, Mass., make a specialty of renewing lamps, and they guarantee all renewed lamps to have an average life of six hundred hours with any selected candle power and wattage. Any engineer wishing to reduce the cost of his incandescent lamp bills can obtain further information by writing the above firm.

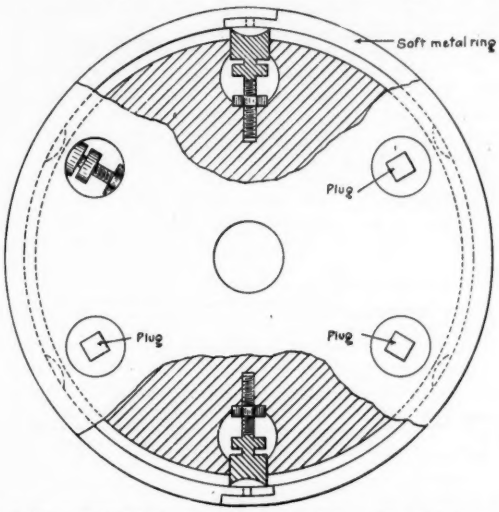
A New Piston.

The accompanying illustrations represents a piston recently patented which has new and improved features of durability and accuracy of adjustment.

It is well known that through constant use a cylinder becomes worn, especially at the lower element of a horizontal cylinder, which makes it impossible to form a steam-tight joint, thus necessitating the reboring of the cylinders from time to time. It is also a known fact that a piston, especially in a high pressure steam cylinder, is subjected to considerable strain.

To overcome these difficulties this piston is provided with a soft metal wear-ring, which will cause but a minimum amount of wear upon the cylinder, and which may be radially expanded at any point sufficiently to compensate for the wear of the ring itself. This ring is formed of a number of sections, so that the sections may at any time be replaced by new sections when the wear renders it desirable. To provide for any strain,

the piston is constructed solid, with radial apertures in which are seated screws for expanding the soft metal wear-ring. The openings in the face of the piston communicate with the radial apertures, permitting the manipulating of the screw



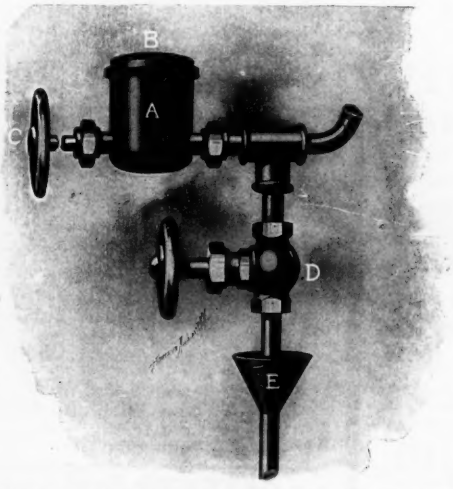
A New Solid Piston with Sectional Soft Metal Rings

from the face of the piston. These openings are provided with closures.

This piston being formed solid possesses the advantages of strength and durability of the piston in common use, known as the "box" piston, but has no plates or followers to become loosened, misplaced or broken. It is the invention of Frank Knothe, of Lowell, Wash.

The "Ideal" Method of Lubricating Metallic Packings on Stationary and Marine Engines.

The durability and life of a metallic packing depends largely upon whether the steam is dry or the boiler's priming and the conditions which surround the rod exterior to the cylinder;



"Ideal" Method of Lubricating Metallic Packings

but whatever the conditions, it is very necessary that the packing and rod be lubricated properly. When operated under the best conditions, there have been instances on record of packings that have run twelve years without repairs or attention, oiling excepted.

The United States Metallic Packing Co., 429 North Thirteenth Street, Philadelphia, make special provision for oiling and draining their metallic packings, as shown in the accompanying illustration of their "Ideal" method of lubricating and draining packings. By this method oil is introduced into the supplementary gland and entirely surrounds the rod between the two sets of packing rings so that the rod is practically travelling through a bath of oil and does not have to be lubricated by swabbing or other outside methods.

When the "Ideal" oiling device is used, a hole is drilled in the packing gland between the inner and outer set of rings. This is normally used as a drain to carry off condensation from between the two sets of packing. With the oiling arrangement, as shown, an oil pump is also attached to this drain, so that the space between the two packings can be filled with oil. The oil pump is then closed off and the drain opened, and as soon as oil appears the drain valve is closed, assuring a bath of oil around the rod and between the two sets of packings.

Engineer Miraculously Escaped Death in Fall From 200-Foot Chimney.

John Nagel, a constructing engineer, fell from the top of a 200-foot chimney at the Standard Steel Car Works in Hammond, Ill., recently, but in his fall he struck a projecting scaffold on the outside, about twenty-five feet from the top, which enabled him to grasp a plank, thus saving his life.

Nagel was in charge of the building of the giant smokestack, and in order to inspect the work he ascended to the top of the structure in a drop bucket. When the bucket neared the top the man in charge of the hoisting engine below failed to perceive Nagel's signal to stop, and the engineer was thrown over the edge of the narrow aperture above.

He escaped practically unhurt, but the other men on the smokestack were so unnerved that they could not work for some time afterward.

Coal Mining Under the Sea.

Up in Cape Breton Island, where there are a great number of collieries digging out coal from under the sea, the submarine area thus undermined now amounts to about sixteen ordinary farms of 100 acres each. The outer end of the hole is something over a mile from shore. Strange as it may seem,the workings have never been invaded by sea water streams, although fresh water streams have been encountered flowing out in the strata under the ocean bed. The thickness of the strata over the mines varies from 500 to 1,140 feet. About 5,250,000 tons of coal have thus far been taken from these submarine workings, and there is as yet no indication of failure of the beds.

Mr. William P. White, formerly of Zanesville, Ohio,, has been appointed District Examiner for the Fifth District of Ohio, consisting of the counties of Ashtabula, Geauga, Lake, Mahoning, Portage, Stark, Summit, and Trumbull. Mr. White will have his headquarters at Room 416, The Arcade, Cleveland. Monday will be examination day at the Cleveland office. Information regarding time of examination at other points will be given any one who writes him.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

The Nason Mfg. Co., 71 Fulton St., New York City, have just issued their new catalog, which describes the Nason steam traps. These traps are noted for their simplicity and accessibility, and are particularly adapted for draining the condensation from steam pipes, coils and apparatus employed in steam heating, vacuum pans, steam engine supply pipes and separators, steam jackets, ice machine stills, etc. These traps are made in three types for different working pressures. Every engineer interested in traps should have this catalog.

Readers who use grease as a lubricant—and those who don't but expect to—should write the Philadelphia Lubricator & Mfg. Co., Bourse Bldg., Philadelphia, for a copy of their catalog describing their automatic grease cut. The feature of interest in this cup is that it feeds by compressed air.

Science is the keynote of success in the boiler compound business, and the wonderful success which the Lake Erie Boiler Compound Co., of Buffalo, N. Y., has had in the scientific manufacture of boiler compound is most convincingly shown by the hundreds of testimonial letters which they have received from their customers, who use Red Star Boiler Com pound.

Even the best of compounds, however, may fail for lack of systematic feeding, so that in connection with the use of Red Star compound, the Lake Erie Boiler Compound Co. will furnish free, any of their different size feeders best suited for the given conditions. A large catalogue describing the proper use of boiler compound will be sent free to any engineer mentioning this paper.

The United States Mineral Wool Co., formerly of 143 Liberty St., New York City, are now occupying their new offices at 140 Cedar St., New York City. The demand for their corrugated copper gaskets has necessitated the change to larger quarters.

A soft packing with a record of three years in an engine without repacking is something to be proud of. The Canfield Mfg. Co., of Philadelphia, are the manufacturers of the "Empire" gum core piston packing, which has given this result. This packing, together with the "Ambest" metallic packing, "Regal" square flax packing, diagonal packings, waterproof hydraulic packing and red sheet packings are described in a neat little 20-page circular issued by them, copy of which, and also a sample can of Ambest metallic packing will be sent free to any reader mentioning THE PRACTICAL ENGINEER.

We are in receipt of a catalog recently issued by the Lippincott Steam Specialty & Supply Co., Newark, N. J., which completely covers their line of Indicators, Reducing Wheels, Planimeters and special attachments, showing operations on a good many of the parts and giving a report of a test in which one of these indicators stood one million, five hundred and ninety-three thousand, seven hundred and sixty strokes under 100 pounds pressure. The catalog also shows a new take-up device, which is included with the Lippincott Reducing Wheel, so that the crosshead cord need not be disconnected in changing. Mr. Lippincott also shows his device for changing the tension of the reducing wheel spring.

The above mentioned catalog will be sent free to any interested engineer.

The Peerless Rubber Mfg. Co. has just broken ground for a large three-story factory building at their plant at New Durham, N. J. This, with other improvements when finished, will give the Peerless Rubber Mfg. Co. the distinction of having by far the largest mechanical rubber plant in the world.

There will be several new calendering machines, a large number of presses for mold work, besides a new installation of washers, grinders, mixers, etc. These improvements when completed will add to the capacity of the plant about 30 per cent.

For the last four years this company has been running both a night and day force, and it is hoped that the new improvements will do away with this necessity.

The department in which the Rainbow and Peerless Packings and the Eclipse Gaskets are manufactured will also be greatly enlarged and improved.

Chas. T. Luce and Geo. U. Ladd have formed a company under the firm name of Chas. T. Luce Co., 160 Congress St., Boston, Mass., to handle high grade power specialties. They are the New England agents for the Diamond Rear Flue Blower and the Diamond Turret Head, which latter is extremely useful whenever it is necessary to bring several tools successively into operation in order to complete a piece of work. It converts a single spindle drill press into a multiple spindle machine, and an ordinary lathe into a turret lathe. They also have the New England agency for the Greenaway Separators, Steam Traps and Exhaust Head, and are agents for the New Bedford Boiler and Machine Co., manufacturers of Extra Heavy Reverse Current Boiler Stop Valves for superheated steam, and the Vertical Foot Valves and for Oil and Waste presses. They are also the exclusive handlers of the Kelley Forced Draft System and the Robinson Fusible Plug, and other power specialties.

Mr. Gardner Cornett, of Providence, R. I., has recently been elected Vice-President of the American Steam Gauge & Valve Manufacturing Company, his office being located at the headquarters of the Company, 220 Camden Street, Boston.

The Goubert Mfg. Co., manufacturers of the well known Goubert Feed Water Heater and the Stratton Separator have moved to 90 West St., New York.

POLARITY INDICATOR 25 CENTS
Works on any voltage. Satisfaction guaranteed or money refunded. Postpaid to any address on receipt of price (coin). J. B. Gravell, 1005 Drexel Building, Phila., Pa.

WANTED—Engineers and mechanics to make big money selling O. K. Hand Soap. A 10-cent can will instantly remove more dirt and stains from the hands than 4 cakes of any soap made, and it will not injure the most delicate skin. Small sample free. O. K. HAND SOAP CO., 570 Columbus Ave., Boston, Mass.

WANTED—Engineers, firemen, electricians and all steam users. Do you want to be "put wise?" Send for 52 page pamphlet containing Questions asked by different Examining Boards throughout the country. Sent FREE. GEO. A. ZELLER BOOK CO., 62 So. 4th St., St. Louis, Mo.

Wanted Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address FRANCE PACKING Co., Tacony, Phila., Pa.

FOR SALE—A fully equipped machine shop, building steam engines and ice machines. Modern buildings, large grounds, and railroad siding. Plenty of orders ahead. Location eastern Pennsylvania. A good opportunity for a mechanical engineer. Box 8, The Practical Engineer, 46 N. 12th Street, Phila.

ENGINEERS. Send your address, and *who employed* by, and we will send you a *Set of Corliss Valve Rod*, or *Throttle Valve Stem Packing free of charge. Express prepaid.* Give *Diameter of rod, Gland, and depth of box.* Ideal Metallic Packing has no *equal.* We have the documents to prove it. Ideal Metallic Packing Co., 419 Mackubin St., St. Paul, Minn.

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In 2 large volumes, containing 1864 pages, 1119 illustrations, 19 pages of colored wirings and 56 large folding drawings.
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New Eighty Page Catalog Free

One of the most artistic and most desirable of catalogs ever issued by an oil-filter concern will be sent you, free, on request. It is devoted to Oil Filters and gives an interesting description of lubricating oil and oiling systems. The latter being illustrated by many fine half-tone cuts.

The section devoted to the "Burt" Ventilator has a large number of high grade half-tones, showing them installed on large manufacturing buildings, and also contains information on the important subject of Ventilation.

The "Burt" and "Standard" Exhaust Heads

are also fully described and illustrated. Every Engineer and every man interested in a manufacturing concern should have a copy of this exceptionally fine catalog.

Do You Want a Copy?

Unit Oil Filters Saves Oil By Washing It

The dirty oil must pass through small perforations and then through filtering cloth to the cylinders, leaving all heavy impurities in the sediment pan.

The oil then goes through animal bone black to the bottom of the filter where it spreads out and is washed by water. All remaining impurities drop to the lower part of filter.

Unit filters save 50 to 90 per cent. of "waste oil" —that's why the Philadelphia Rapid Transit Company uses 22 of them.

The Best Device For Muffling The Exhaust Pipe

is the Burt Exhaust Head. It never fails to completely separate all moisture and oil from escaping steam.

It has no baffle plates or diaphragms. Is made from heavy iron, securely lapped, riveted and soldered. It doesn't get out of order.

Its worth is proven by the fact that the Baldwin Locomotive Works uses 53 of them and the United States Steel Corporation 95.

The Burt Manufacturing Company, Largest Manufacturers of Oil Filters in the World
204 MAIN ST., AKRON, O, U. S. A.

ALSO SUPPLIED BY ENGINE BUILDERS, DEALERS AND POWER CONTRACTORS

A Gauge Glass Cutter free is offered by the Geo. W. Lord Co. to engineers who send sample of scale from their boiler for free analysis. See advertisement on another page of this issue.

The Homestead Valve Mfg. Co., of Pittsburg, Pa., have engaged Mr. P. L. Rhodes, formerly with the Pittsburg Supply Co., as sales manager to succeed Mr. C. B. Ault, who has resigned to enter another line of business.

O. F. Zurn Co., the popular Philadelphia oil house, has moved to new quarters on Broad Street above Lehigh Ave., where they have purchased a large property with a frontage of fifty feet on Broad Street and extending back 349 feet to the Reading Railway tracks. Contracts have been awarded for alterations that will convert the large building into one of the finest and most complete oil houses in the east, with immense storage tanks and the latest and most modern facilities for compounding. A railroad siding runs right into the building, which facilitates the loading and unloading of car-load lots and tank cars. As soon as the improvements to the main building are completed a new office building 50 x 60 feet will be erected on the Broad Street front. Their specialties are Zurnoil for automobiles, Peerless Boiler Cleaning Compound, Oleaqua for Hydraulic Elevator Systems, Turkish Softener, Resolvent Compound and the "old reliables" Royal A, Cylinder Oil and Royal Dynamo Oil. Remember the new address, Broad St. above Lehigh Ave.

This is a good time to get busy overhauling the heating plant while the defects and difficulties encountered last winter are fresh in your mind. Don't put it off until the last horn blows for winter again, or there may be brain storms, and while you are at it, or before you begin, it might be a good plan to find out more about that Receiver and Oil Separator made by Walter J. McKnight, Buffalo, N. Y. He will mail you circulars and tell you what it's doing for other heating systems, where it is in operation, if you write him.

The Buckeye Boiler Skimmer has received the following letter from The Van Camp Packing Co., of Indianapolis.

Gentlemen:—The four Skimmers installed in our boilers on November 26th, 1906, are doing all that you claimed for them. As we had troubles too numerous to mention, priming being the worst.

The writer was doubtful about the Skimmers being able to overcome all these difficulties. However, they are making good; keep the boilers practically clean, save fuel, and fully 90 per cent. on repairs, and will soon have the credit to their account. They are handling large quantities of clay and magnesia, and give us clean, dry steam. We consider the Skimmer a great invention and cheerfully recommend it to all steam users.

Very truly yours,
THE VAN CAMP PACKING CO.,
By B. E. Taylor, Supt.

The Pittsburg Gage & Supply Co., Pittsburgh, has recently installed White Star oiling systems in the engine rooms of the following concerns: Cincinnati Water Works, Cincinnati, Ohio; Standard Underground Cable Co., Perth Amboy, N. J.; Warner & Swasey Co., Cleveland, Ohio; Baldwin Steel Co., Charleston, W. Va., New River & P. Coal Co., Berwind, W. Va.; Berwind White Coal Mining Co., Windber, Pa.; John Wanamaker, New York, N. Y.; Pittsfield Electric St. Ry Co., Pittsfield, Mass.; John Roebling Sons Co., Kinkara, N. J.; Bryan-Marsh Electric Co., Central Falls, R. I.; Louisville Lighting Co., Louisville, Ky. This modern method of lubricating engine bearings is fully illustrated and described in a new catalog published by the above company.

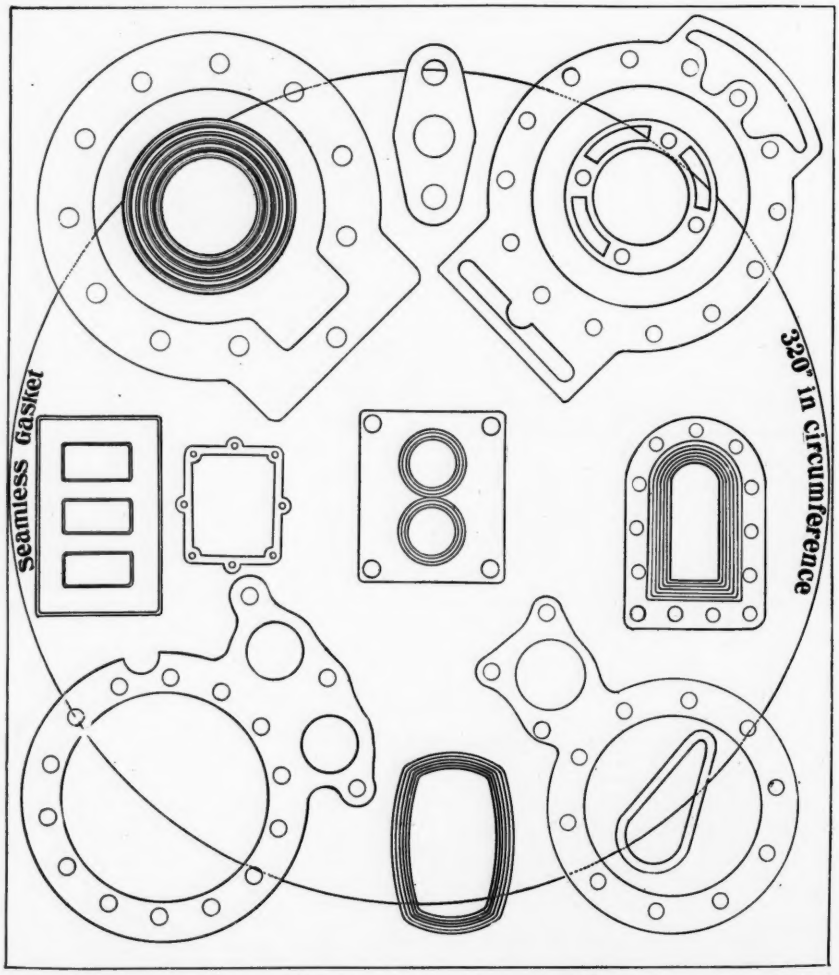
U. S. INDESTRUCTIBLE ELASTIC METAL GASKETS

Metallic gaskets are being used more widely every day for all kinds of boilers, flange joints, manholes and handholes, mud drums, steam traps,, cylinder heads, flange and lip unions, oil tanks, ammonia fittings, air, steam and oil pumps, heater and tanks. The gaskets are generally made of sheet metal, stamped with concentric corrugations. The metal may be of copper, lead, bronze, brass or nickeled steel, and for special purposes wood, silver or other material may be used.

A corrugated gasket is a series of arches, the concentric corrugations forming a series of dams and points of contact over which nothing can pass. Six to eight corrugations are all that are necessary, so that the space within the bolt holes usually determines the width of the gasket. Connections made with these gaskets are not likely to blow out after continued use, as each corrugation makes the entire circle of the flange, and so long as the contact is kept complete by compression, the joint cannot leak. They may be put in place while steam is leaking, and expansion and contraction does not impair their efficiency.

The accompanying illustrations show some of the various types of indestructible gaskets that have been manufactured by the U. S Indestructible Gasket Co., 16 S. William St., New York, who can furnish all sizes of corrugated copper or lead gaskets and who will make seamless gaskets of every size or shape for steam chests, cylinder heads, valve bonnets, etc., to order. It is only necessary to send them a rough pencil sketch showing shape and size wanted. A descriptive circular and price list will be mailed to any reader asking for it.

The New York offices of the Sterling Blower & Pipe Manufacturing Co., of Hartford Conn., have been moved to 109 Liberty St.



The D. T. Williams Valve Co., of Cincinnati, Ohio, have recently issued a small booklet, illustrative and descriptive of their complete line of oil and grease cups, which is very comprehensive in its variety. These cups are all made strong and durable, and the careful workmanship and selected material used in their manufacture have been one of the many reasons why the name "Williams" and "quality" are so closely associated. All products of the Williams factory undergo a rigid system of inspection, which enables them to guarantee all their products. Any engineer interested in oil or grease cup should write for this booklet, as the variety shown therein will be found to meet the requirements of most any kind of service.